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SEDIMENTS

Mr. James Saric
Remedial Project Manager
USEPA Region 5
77 West Jackson Boulevard
Mail Code: SR-6J
Chicago, IL 60605-3507

Subject:
Final Area 1 Work Plan Supplement:
Baseline Ecological Risk Assessment Work Plan
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Date:
July 20, 2010

Contact:
Michael J. Erickson

Phone:
810.225.1924

Email:
michael.erickson@arcadis-us.com

Our ref:
B0064539

Dear Mr. Saric:

On behalf of Georgia-Pacific LLC (Georgia-Pacific), please find enclosed the revised final *Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan* (Area 1 BERA Work Plan). This revised final document supersedes the version submitted to you on June 24, 2010, which was modified as requested by the U.S. Environmental Protection Agency (USEPA). In response to your e-mail dated July 6, 2010, Appendix A has been eliminated and the work group process for development of the Exposure Point Concentration (EPC) approach is specifically referenced. Please remove the June 2010 version from your files and replace it with this submittal.

The remainder of this letter includes a summary of the development process for this document, along with a description of other changes made to finalize the work plan since the receipt of conditional approval from USEPA in May 2010.

The Area 1 BERA Work Plan, which was developed to satisfy the requirements of Sections 2.3.2 and 2.3.3 of the Statement of Work (SOW) attached to the Administrative Settlement Agreement and Order on Consent (AOC) for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. V-W-07-C-864), was originally submitted on June 30, 2009. Georgia-Pacific revised and resubmitted the document on November 20, 2009 following a collaborative review and revision process with technical representatives of the USEPA, the Michigan Department of Natural Resources and Environment (MDNRE), and the Natural Resource Trustees.

Georgia-Pacific received written comments on the November 2009 version of the Area 1 BERA Work Plan from USEPA and MDNRE, dated February 25, 2010 and February 26, 2010, respectively. Georgia-Pacific submitted a response to comments document on April 5, 2010 clearly identifying how the work plan would be revised to address the comments. With the exception of one issue associated with USEPA original specific comment #5, USEPA determined that the responses to comments were adequate, and provided written conditional approval of the Area 1 BERA Work Plan on May 25, 2010. Georgia-Pacific agreed to revise the response to specific comment #5 before submitting the final work plan.

USEPA's specific comment #5 was in regard to the dietary composition for the American woodcock. Georgia-Pacific has incorporated the required revision based on the Krohn (1970) study with a slight modification to what was outlined in USEPA's May 2010 letter. The original dietary composition breakdown for the Krohn study is slightly misrepresented in USEPA's Wildlife Exposure Factors Handbook (USEPA 1993). Krohn did not present dietary data for woods and fields separately in the 1970 study – the differences in the woods and fields habitats data provided in USEPA 1993 are due to imprecise presentation of the underlying data. Both sets of numbers are based on the same dataset, which includes woodcocks in fields. As such, the dietary composition for the woodcock is 83.2% worms and 16.8% other invertebrates. These percentages were derived from the data in the original study with grit excluded as a portion of the diet. No wet-weight-based studies were available for the shrew. As a result, the dietary composition was not revised from the volumetric basis included in the April 2010 responses. Uncertainties will be discussed in the BERA.

If you have any questions, please do not hesitate to contact us.

Sincerely,
ARCADIS

Michael J. Erickson, P.E.
Vice President

Enclosures: James Saric (two copies)

Copies:
Frank Dillon, CH2M HILL, 1 copy
Jeff Keiser, CH2M HILL
Todd Goeks, NOAA

Lisa Williams, USFWS
Sharon Hanshue, MDNRE
Paul Bucholtz, MDNRE, 1 copy
Garry Griffith, Georgia-Pacific LLC, 1 copy
Mark P. Brown, Ph.D., Waterviews, LLC
Martin E. Lebo, Ph.D., Weyerhaeuser Company, 1 copy
Kenneth Jenkins, Ph.D.

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Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan

Georgia-Pacific LLC

July 2010

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF:

May 25, 2010

Mr. Michael J. Erickson SR-6J
Associate Vice President/Principal Engineer
ARCADIS
10559 Citation Drive, Suite 100
Brighton, MI 48116

RE: Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan (Revised)

Dear Mr. Erickson:

The United States Environmental Protection Agency (EPA) has completed its review of the April 5, 2010, responses to comments and the revised Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site.

The responses have adequately addressed EPA's previous comments and incorporated them into the revised document, with the exception of one comment (EPA original specific comment #5). EPA has enclosed the specific required revision to that comment that must be incorporated into the final document.

Therefore, EPA approves the Area 1 Baseline Ecological Risk Assessment Work Plan pending receipt of adequate responses to the enclosed comment and a revised final document incorporating that comment. The responses to the enclosed comment and revised document must be submitted within (45) forty-five days of receipt of this letter.

Please contact me at (312) 886-0992 if you have any questions regarding this matter.

Sincerely,

James A. Saric
Remedial Project Manager
SFD Remedial Response Branch #1

Enclosure

cc: Paul Bucholtz, MDEQ
Gary Griffith, Georgia-Pacific
Richard Gay, Weyerhaeuser

Bcc w/enclosure:

Jeff Keiser, CH2MHILL
Leslie Kirby-Miles, ORC
James Chapman, SFD

U.S. EPA COMMENTS ON THE REVISED AREA 1 BASELINE ECOLOGICAL RISK ASSESSMENT WORK PLAN

Response to Original Comment #5:

3.4.1.1.2 Dietary Composition

The best estimate for woodcock dietary composition is Krohn (1970) because data are reported as % wet weight, which is the appropriate unit for exposure modeling since PCB concentrations in prey are reported on a wet-weight basis, not volumetric. The high fraction of grit reported by Krohn (1970) is not problematic because it can be removed and the prey composition recalculated without grit. Krohn (1970) reports dietary composition for woodcock in two habitats, woods and fields. The dietary composition in woods is 83.4 % earthworms and 16.6 % other terrestrial invertebrates (values reported without grit) (Krohn 1970 in U.S. EPA 1993). The dietary composition in fields is 84.1 % earthworms and 15.9 % other terrestrial invertebrates (including 1 % "other"), recalculated excluding the grit component (Krohn 1970 in U.S. EPA 1993). Combining woods and fields woodcock results in 84 % earthworm and 16 % other terrestrial invertebrates.

Sperry (1940) woodcock dietary composition is inappropriate because it is reported as % volume, which is incommensurate with exposure data.

Krohn, W. 1970. Woodcock feeding habits as related to summer field usage in central Maine. J Wildl Manage 34: 769-775.

Sperry, C. 1940. Food habits of a group of shore birds; woodcock, snipe, knot, and dowitcher. U.S. Dept. Int., Bur. Biol. Survey, Wildl Res Bull 1. 37 pp.

U.S. EPA. 1993. Wildlife Exposure Factors Handbook. vol. I and II. Office of Research and Development. EPA/600/R-93/187a and b.

The proposed shrew dietary composition is reported on a volumetric basis, not on a wet-weight basis commensurate with prey PCB data. It may be used only if wet-weight dietary composition data are unavailable, in which case the uncertainty for exposure modeling should be discussed.

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Allied Paper, Inc./Portage Creek/
Kalamazoo River Superfund Site

Supplemental Remedial Investigations/
Feasibility Studies

Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan

Georgia-Pacific, LLC

July 2010

ARCADIS

Michael J. Erickson, P.E.
SRI/FS Program Coordinator

Kenneth D. Jenkins, PhD

Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan

Allied Paper, Inc./Portage Creek/ Kalamazoo River Superfund Site

Supplemental Remedial Investigations/Feasibility Studies

Prepared for:
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Our Ref.:
B0064539.00771

Date:
July 2010

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Acronyms and Abbreviations

AE	assessment endpoint
AOC	Agreement and Order on Consent
BAF	bioaccumulation factor
BBL	Blasland, Bouck & Lee, Inc
BERA	Baseline Ecological Risk Assessment
BW	body weight
CDM	Camp, Dresser & McKee
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
COCs	constituents of concern
CSM	Conceptual Site Model
DQOs	data quality objectives
dw	dry weight
EcoSSL	Ecological Soil Screening Guidance
EPCs	exposure point concentrations
EU	exposure unit
FIR	food ingestion rate
FS	Feasibility Study
g/day	gram per day
HQ	hazard quotient
kg	kilograms
KRSG	Kalamazoo River Study Group
LOAEL	lowest observed adverse effects level
LOE	line of evidence
MDEQ	Michigan Department of Environmental Quality
ME	measurement endpoint
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
MHLLC	Millennium Holdings, LLC
MSU	Michigan State University
NOAEL	no observed adverse effects level
OSWER	Office of Solid Waste and Emergency Response

OU5	Operable Unit 5
PCBs	polychlorinated biphenyls
RMCs	Risk-Based Media Concentrations
RA Framework	Risk Assessment Framework
RMC	risk-based media concentration
SOW	Statement of Work
SRIs/FSs	supplemental remedial investigations and feasibility studies
SUF	site use factor
TBSA	Terrestrial Biota Sampling Area
TCRA	time-critical removal action
TEQs	toxic equivalents
TERA	Terrestrial Ecological Risk Assessment
TRVs	toxicity reference values
USEPA	U.S. Environmental Protection Agency
ww	wet weight
95 UCL	95 percent upper confidence limit

1. Introduction

On February 21, 2007, Georgia-Pacific LLC (Georgia-Pacific) and Millennium Holdings, LLC (MHLLC), collectively referred to as the Kalamazoo River Study Group (KRSG), voluntarily entered into an Administrative Settlement Agreement and Order on Consent (AOC) with the U.S. Environmental Protection Agency (USEPA). This agreement, which describes a series of supplemental remedial investigations and feasibility studies (SRIs/FSs) that will be carried out over the next several years, is referred to as the SRI/FS AOC (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. V-W-07-C-864). The SRI/FS work will take place primarily in Operable Unit 5 (OU5) of the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Site or Superfund Site), located in Kalamazoo and Allegan Counties in southwest Michigan (Figure 1-1). OU5 encompasses 80 miles of the Kalamazoo River, including a stretch of Portage Creek from Alcott Street to its confluence with the Kalamazoo River (Figure 1-1).

The Statement of Work (SOW) included as Attachment A to the SRI/FS AOC directs that, as part of SRI/FS activities, the KRSG will prepare a new baseline human health and ecological risk assessment for each of the seven geographic Areas of OU5 defined in the SOW. The ultimate purpose of each Area-specific risk assessment will be to support Area-specific risk management and remedial decision-making. The process for implementing the Area-specific risk assessments was established in the Risk Assessment Framework (RA Framework) (ARCADIS 2008), as required by the SOW. In accordance with the RA Framework (ARCADIS 2008), the Area-specific risk assessments will be based on Area-specific risk assessment work plans that will be prepared as a part of the SRI/FS process. As described in the RA Framework (ARCADIS 2008), the Area-specific risk assessments will build upon the information presented in the existing USEPA-approved Camp, Dresser & McKee (CDM) risk assessments (CDM 2003a, b) and the Generalized Conceptual Site Model for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Generalized CSM, ARCADIS 2009).

Since CDM developed its assessments, USEPA has issued additional risk assessment guidance, relevant research has been presented in the scientific literature, and additional sampling has been conducted and is planned at the Site. In addition, in Area 1, since the finalization of the CDM risk assessments, the KRSG completed a time-critical removal action (TCRA) in the former Plainwell Impoundment in 2008 and 2009, and a TCRA is also underway in the Plainwell No. 2 Dam Area. Source control activities have also been completed or are underway at the former mill properties and landfill areas. Benefits of these removal and source control actions are expected to extend to the whole Site, affecting transport and reducing exposures and potential risks by decreasing polychlorinated biphenyl

(PCB) levels in water, sediment, and biota. These actions, along with natural processes, have resulted and are expected to continue to result in changes in exposure concentrations of PCBs present in environmental media in Area 1 compared to those reflected in the CDM risk assessments (CDM 2003a,b).

The Area-specific baseline risk assessments will incorporate current Agency guidance, current science, and new data, as appropriate based on Area-specific considerations. The dataset to be used in the new risk assessment work will exclude prior samples in locations affected by the TCRA activities and will incorporate available post-removal samples. The Area-specific baseline risk assessments will also present risk-based media concentrations (RMCs). The RMCs will be used as a basis to develop and consider the potential relative risk reduction associated with various remedial alternatives evaluated in the Feasibility Study (FS) for each Area.

The RA Framework provides for flexibility in meeting risk assessment requirements on an Area-by-Area basis. For example, the RA Framework states that:

> "At a minimum, updated risk calculations are anticipated to be performed for each Area by incorporating more recent exposure data (e.g., new measurements of polychlorinated biphenyl (PCB) concentrations in soil, sediment, water, or fish). In conducting future Area-specific risk assessment work, the basis for changes from the CDM risk assessment methodology or inputs may also include the incorporation of new data, new science, new guidance, or new methodologies acceptable to USEPA that are current at the time each work plan is prepared." (RA Framework, p. 1-1)

and

> "…[I]n the interest of streamlining the process, for some Areas KRSG may propose little or no additional risk assessment work and may instead rely upon either the USEPA-approved CDM risk assessment work and/or USEPA-approved risk assessment work for other Areas in whole or in part. Area-specific risk assessments may be completed by referencing relevant prior USEPA-approved risk assessment work (either the CDM reports or another Area-specific assessment) and updating or revisiting only those factors that are unique to the Area in question." (RA Framework, p. 1-2)

1.1 Risk Assessment Work Plan Development

As described in the SRI/FS AOC and the SOW, the development of the Area-specific risk assessments will be a collaborative process between KRSG and USEPA, with the Michigan Department of Environmental Quality (MDEQ) having the opportunity to participate. This document is a revised first draft that has been substantially reduced based on agreements that have been reached through this collaborative process to date. Specifically, it has been agreed by the KRSG and USEPA that the human health risk assessment (HHRA) requirements for Area 1 will be met by incorporating by reference the methodology, exposure factor values, and key findings from the CDM HHRA (CDM 2003b). Although it would be possible to prepare an extensive update to the CDM HHRA that incorporates new science, new guidance, and new methodologies, in consideration of the immediate needs for risk management and remedial decision-making at Area 1, and in the interest of streamlining the process, new HHRA work undertaken for the Area 1 SRI/FS will be limited to preparation of updated risk estimates for fish consumers. These updated risk estimates will be based on more recent measurements of PCB concentrations in fish tissue than the data from 1993 upon which CDM relied. Given the limited scope of these HHRA activities, a separate HHRA report will not be prepared for Area 1; instead, the updated risk estimates will be appended to and discussed within the SRI/FS report.

It has also been agreed that the aquatic portion of the Final (Revised) Baseline Ecological Risk Assessment (Site-Wide BERA) conducted by CDM (CDM 2003a) will not be revisited for Area 1. Thus, this *Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan* (Area 1 BERA Work Plan) has been prepared to describe the process for conducting a terrestrial BERA for Area 1, which includes the area from Morrow Dam to Plainwell Dam and a stretch of Portage Creek (Figure 1-2)[1]. Since CDM developed its Site-Wide BERA, researchers at Michigan State University (MSU) completed ecological studies on behalf of the KRSG from1999 to 2003. In accordance with the SOW, a peer review of these studies was completed, which provided guidance as to whether and how the MSU studies and data should be incorporated in the Area-specific BERAs (Dickson et al. 2008). The incorporation of these studies and data into the Area 1 BERA is discussed in Section 3. In accordance with the RA Framework, this BERA Work Plan identifies the aspects of the CDM Site-Wide BERA that will be revised for the Area 1 BERA. Where alternative assumptions or inputs are included, appropriate rationale is provided.

[1] This ERAWP is presented as a supplement because the SRI/FS Work Plan for Area 1 was submitted to and approved by USEPA in February 2007 as part of the AOC/SOW development. ERAWPs for Areas 2-7 will be included as an element of those Area-specific SRI/FS Work Plans.

Other specific technical issues that have been agreed upon or will require resolution after submittal of this BERA Work Plan are discussed in the appropriate sections of this document. It is anticipated that the parties will continue to meet, confer, and exchange information during the process, with the goal of resolving key issues prior to submittal of the final Area 1 BERA.

The remainder of Section 1 provides an overview of the general approach for the Area 1 BERA and an outline of this document.

1.2 Area 1 Baseline Ecological Risk Assessment Approach

The purpose of the Area 1 BERA is to determine whether PCBs remaining within Area 1 pose a current or potential risk to ecological receptors, and if so, to calculate RMCs for PCBs in relevant environmental media based on target risk levels. As described in the RA Framework (ARCADIS 2008), the Area 1 BERA will use the inputs to CDM's Site-Wide BERA (CDM 2003a) as a point of departure. The Area 1 BERA will not revisit the risk calculations for the sediment-based (i.e., aquatic) food chain assessment. The terrestrial food chain assessment will include the approach used in CDM's Site-Wide BERA, and will incorporate new lines of evidence and/or revised inputs where supported by the Peer Review of the MSU ecological studies, the available literature, or Area-specific data.

The Area 1 BERA will follow the process outlined in the USEPA Superfund Guidance for Ecological Risk Assessment (USEPA 1997a). However, because each Area has previously been evaluated as a part of CDM's Site-Wide BERA (CDM 2003a), the first two screening steps in the eight-step process (e.g., Screening Level Problem Formulation and Effects Evaluation and Preliminary Exposure Estimates and Risk Calculations) specified by USEPA (1997a) will not be conducted for the Area 1 BERA. Thus, the Area 1 BERA will begin with Step 3, the BERA Problem Formulation. The problem formulation (Section 2 of this Area 1 BERA Work Plan) includes the development of the ecological Conceptual Site Model (CSM)[2], and identification of assessment endpoints (AEs), measurement endpoints (MEs), and representative receptors. The Data Quality Objective (DQO) portion of Step 4 (Study Design and Data Quality Objective Process) is addressed in Section 6 of this Area 1 BERA Work Plan. Study Design (Step 4) as well as any necessary field verification of sampling design (Step 5) for any additional sampling that may be conducted would be addressed through separate planning documents to be approved by USEPA. An Exposure and Effects Assessment (Step 6) to estimate potential exposure to each identified receptor and identify appropriate toxicity

[2] A general CSM for ecological risk assessment has been approved in the Generalized Conceptual Site Model (ARCADIS 2009) and was used as the basis for the Area 1- specific CSM.

and/or effects data will be included in the Area 1 BERA as described in Sections 3 and 4, respectively, of this Area 1 BERA Work Plan. Finally, the Risk Characterization (Step 7) will incorporate multiple lines of evidence, including hazard quotient- (HQ-) based risk estimates for each AE (Section 5). The risk characterization will also include a detailed uncertainty analysis. Following the uncertainty analysis, and based on the complete interpretation of all lines of evidence, RMCs will be developed for receptors that are found to be potentially at risk. It is expected that the RMCs will aid in the risk management process (Step 8) that will follow development of the risk assessment.

1.3 Document Organization

The remainder of this Area 1 BERA Work Plan includes the following sections:

Section 2 – Problem Formulation

Section 3 – Exposure Assessment

Section 4 – Effects Assessment

Section 5 – Risk Characterization

Section 6 – Available Data and Data Quality Considerations

Section 7 – References

2. Problem Formulation

The problem formulation includes selection of constituents of concern (COCs), the development of an ecological CSM, the selection of AEs and MEs, and the identification of representative receptors. Each of these elements is discussed below. The AEs, MEs, and representative receptors are also summarized in the DQO table (6-1) provided in Section 6.

2.1 COC Selection

As described in the Generalized CSM (ARCADIS 2009), the Site data, which have been presented in a variety of documents, indicate that PCBs are the primary COC. Prior investigation work has included sampling for other constituents in sediments, soils, and fish. The available data indicate that exposure to PCBs will drive potential risks at the Site, and that management of risks due to PCB exposure will also address potential risks associated with other constituents. CDM's Site-Wide BERA (CDM 2003a) states:

> "PCB contamination is considered to be the primary focus of this ERA because of the current magnitude and distribution of PCBs throughout the API/PC/KR (Figure 2-1, presented in Section 2 and discussion of Stressor Identification in Section 3.1). This ERA, therefore, does not consider the additional incremental effects that may be caused by other chemical stressors..."

Consistent with the CDM Site-Wide BERA (CDM 2003a), PCBs are the only COC that will be evaluated in the Area 1 BERA. PCB exposure and effects will be assessed based on total PCBs for all identified receptors and as both total PCBs and congener-based dioxin toxicity equivalents (TEQs) for a subset of receptors and exposure pathways. The receptors that will be evaluated based on TEQs will be determined based on the availability of appropriate toxicity data for developing toxicity reference values (TRVs). This is discussed in more detail in Section 2.4.

2.2 Area-Specific Ecological CSM

Generalized CSMs for both aquatic and terrestrial habitats were presented in the Generalized CSM document (ARCADIS 2009). However, as stated previously in Section 1, the aquatic portion of the Site-Wide BERA conducted by CDM (CDM 2003a) will not be revisited for Area 1. Therefore, this section focuses of the terrestrial CSM for Area 1. The terrestrial CSM for Area 1 is modified from the Generalized CSM (ARCADIS 2009) to include the identification and evaluation of complete exposure pathways for insectivorous birds and vermivorous mammals. Factors considered in the development of the Area 1 terrestrial CSM include critical fate and

transport routes, the potential for contaminant migration and bioavailability, and characterization of particular habitats. The terrestrial CSM is illustrated in Figure 2-1.

For the terrestrial habitats within Area 1, complete pathways were identified between:

- exposed sediments/contaminated prey and omnivorous birds and mammals,
- exposed sediments/contaminated prey and insectivorous birds and mammals,
- exposed sediments/contaminated prey and vermivorous birds and mammals, and
- exposed sediments/contaminated prey and carnivorous birds and mammals.

Based on what is known about the dietary components of each of these receptor feeding guilds, the omnivorous species which consume a significant portion of vegetation in their diets are expected to be less exposed than insectivorous, vermivorous, or carnivorous species. Therefore, omnivores will not be quantitatively evaluated, and the evaluation of the other more highly exposed feeding guilds will be considered protective of omnivorous species. Likewise, the evaluation of the northern short-tailed shrew (i.e., a vermivorous mammal) will be considered adequately representative of insectivorous mammals. Receptor guilds that will be evaluated quantitatively include insectivorous birds, vermivorous birds and mammals, and carnivorous birds and mammals.

2.3 Area-Specific Assessment Endpoints

AEs are formal expressions of the actual environmental value to be protected from risk (Suter et al. 1993) and are typically tied directly to specific ecological values needing protection. Furthermore, AEs provide a clear logical connection between regulatory policy goals and anticipated ecotoxicological investigations.

The terrestrial AEs identified for Area 1 are based on the complete pathways identified in the Area 1 CSM (Figure 2-1). In addition, consistent with the USEPA's Office of Solid Waste and Emergency Response (OSWER) Directive "Ecological Risk Assessment and Risk Management Principals for Superfund Sites" (USEPA 1999), Principal 1: "Superfund's goal is to reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota", each AE is intended to protect the local populations of the identified resources. The selected AEs are also comprehensive of those identified in the CDM Site-Wide BERA (CDM 2003a). The proposed AEs described in this section are incorporated into the DQOs presented in Section 6 and are listed below.

- Sustainability of local insectivorous bird populations
- Sustainability of local vermivorous bird populations
- Sustainability of local carnivorous bird populations
- Sustainability of local vermivorous mammal populations
- Sustainability of local carnivorous mammal populations

The receptor guilds identified in the AEs were selected for the Area 1 BERA by considering the receptors evaluated in the CDM Site-Wide BERA (CDM 2003a) as well as Site ecology and other relevant Site investigations (e.g., MSU passerine reproductive studies).

Once the receptor guilds were identified, specific surrogate, or representative, species were selected to represent all wildlife receptors in that feeding guild. The surrogate species chosen are those likely to be present within Area 1, have exposure parameters available in literature, and represent the high end of potential exposures. The receptors selected, and their relationship to those considered in the CDM Site-Wide BERA (CDM 2003a), are as follows:

- The house wren, a new receptor, was added to represent the insectivorous bird feeding guild.
- The northern short-tailed shrew was selected to represent vermivorous (and insectivorous) mammals as an alternative to the white-footed mouse, which was previously evaluated in the Site-Wide BERA (CDM 2003a) as an omnivorous mammal.
- The American woodcock was selected, in addition to the American robin which was evaluated in the Site-Wide BERA (CDM 2003a) to evaluate vermivorous birds.
- The red-tailed hawk was selected to represent terrestrial-feeding carnivorous birds as an alternative to the great horned owl, which was evaluated in the Site-Wide BERA (CDM 2003a) and has a mixed aquatic and terrestrial diet.
- The red fox was selected to represent carnivorous mammals, consistent with the CDM Site-Wide BERA (CDM 2003a).

2.4 Area-Specific Measurement Endpoints

The AEs described above cannot be directly measured; rather, an ME related to the AE is evaluated. MEs are quantitative expressions of observable or measureable changes that are used to evaluate the effects of chemical stressors on the receptor species AEs (USEPA 1997a). Effects on selected MEs are then used to make inferences about potential effects to the AEs. The proposed MEs described in this section are incorporated into the DQOs discussed and presented in Section 6. In addition to the MEs discussed below, other lines of evidence will be considered for each AE as available. Section 5 provides additional detail on other lines of evidence.

Because almost all of the data available for Area 1 are total PCB data measured as Aroclors, the MEs will focus on the evaluation of risk associated with exposure to total PCBs. In addition, at the request of USEPA, risk associated with exposure to TEQs will be considered for a subset of the receptors evaluated. A TEQ-based analysis requires individual PCB congener data for a set of 16 non- and mono-ortho substituted PCBs. However, as TEQ data are not currently available for Area 1, estimates of exposure to TEQs will be based on modeled TEQ concentrations (based on the MSU dataset as described in Section 3.5). This introduces an added level of uncertainty to the TEQ-based risk estimates due to the added step of modeling TEQs from already modeled total PCB concentrations. In addition, sufficient toxicity data may not be available to support development of acceptable TRVs for all exposure pathways and receptors. Therefore, the determination of whether TEQs will be evaluated for specific pathways and receptors will be made during the TRV development process that will be conducted prior to completion of the Area 1 BERA (See Section 4). The MEs that will be used to evaluate each AE are listed below.

Insectivorous birds:

1) Calculate HQs by comparing a total PCB-based and possibly TEQ[3], modeled, daily, dietary dose for the house wren to relevant toxicity thresholds from the peer reviewed literature that are protective of local population health.

2) Calculate HQs by comparing a modeled, egg TEQ and possibly a total PCB-based[4] exposure for the house wren to relevant toxicity thresholds from the peer reviewed literature that are protective of local population health.

[3] The determination of whether these exposure pathways will be evaluated based on total PCBs and/or TEQs will be based on the outcome of the TRV development process (See section 4 for additional detail on TRV development).

3) Evaluate the results of MSU reproductive studies for insectivorous birds conducted within other Areas of OU5 and their relevance to the sustainability of local insectivorous bird populations in Area 1.

Vermivorous birds:

1) Calculate HQs by comparing a total PCB-based and possibly TEQ[4]-based, modeled, daily, dietary dose for the American woodcock and American robin to relevant toxicity thresholds from the peer reviewed literature that are protective of local population health.

2) Calculate HQs by comparing a TEQ-based and possibly a total PCB-based[4], modeled, egg exposure for the American woodcock and American robin to relevant toxicity thresholds from the peer reviewed literature that are protective of local population health.

Vermivorous mammals:

1) Calculate HQs by comparing a total PCB-based and possibly TEQ[4]-based, modeled, daily, dietary dose for the northern short-tailed shrew to relevant toxicity thresholds from the peer reviewed literature that are protective of local population health.

Carnivorous birds:

1) Calculate HQs by comparing a total PCB-based, modeled, daily, dietary dose for the red-tailed hawk to relevant toxicity thresholds from the peer reviewed literature that are protective of local population health.

Carnivorous mammals:

1) Calculate HQs by comparing a total PCB-based, modeled, daily, dietary dose for the red fox to relevant toxicity thresholds from the peer reviewed literature that are protective of local population health.

[4] The determination of whether these exposure pathways will be evaluated based on total PCBs and/or TEQs will be based on the outcome of the TRV development process (See section 4 for additional detail on TRV development).

3. Exposure Assessment

This section describes the exposure assessment methods that will be used in the Area 1 BERA for the HQ-based lines of evidence. The exposure assessment evaluates the potential for exposure to chemical stressors (i.e., COCs) by evaluating the co-occurrence of the stressors and the ecological receptors (USEPA 1998). This exposure assessment includes the determination of primary and secondary exposure media and primary exposure media depth interval, discussion of the appropriate spatial scale of exposure units (EUs) for the AEs identified, methods for development of exposure point concentrations (EPCs) for each exposure medium, and approaches for estimation of dietary and egg-based exposures. Each of these elements is discussed below.

3.1 Primary and Secondary Exposure Media

Because it has been agreed that the Area 1 BERA will not revisit the aquatic portion of the CDM Site-Wide BERA (2003a), only media associated with the terrestrial environment are considered exposure media in this assessment. Primary exposure media are media in which PCBs have been directly deposited from historical sources (e.g., exposed sediments and in-stream sediments). Secondary exposure media are media in which COPECs are present as a result of contact with primary exposure media. Primary and secondary exposure media are discussed below for Area 1. Details regarding the specific data available for each medium for Area 1 are included in Section 6.

3.1.1 Primary Exposure Media - Exposed Sediments

Exposed sediments are the only primary exposure media for the terrestrial portion of Area 1. Exposed sediments are those soils in areas that were inundated when the former dams were in operation. This includes the formerly impounded area upstream of the former Plainwell Dam and the historically inundated area upstream of the Plainwell No. 2 Dam. The former Plainwell Dam was drawn down in the 1970s, removed to its sill in 1987, and bypassed completely in 2009 as part of the Plainwell TCRA. At the dam site, the river has been restored to its former channel. The diversion structures of the Plainwell No. 2 Dam did not create an impoundment, as the dam's primary purpose was to direct water into a mill race, however, the upstream area was occasionally inundated during periods of high flow. The PCBs in the exposed sediments were deposited upstream of the dams during periods when these areas were underwater. The completed and ongoing removal activities in these areas will stabilize eroding banks and address a portion of PCB-containing exposed sediments. The residual post-construction PCB concentrations in the exposed sediments within these two areas will be evaluated as a primary

exposure medium in the Area 1 BERA. The approximate extents of these formerly inundated areas are shown in Figures 3-1 and 3-2.

3.1.2 Secondary Exposure Media - Biotic Prey Tissue

Secondary exposure media for the Area 1 BERA include biotic tissues from species that are considered prey items for the representative receptors identified in Section 2.3. These include terrestrial plants, terrestrial invertebrates (including earthworms), small mammals, and birds. Available terrestrial biota PCB data for Area 1 include earthworms, small mammals (mice), and adult birds (robins). Data for earthworms and mice were collected from one sampling grid in Area 1 (Terrestrial Biota Sampling Area [TBSA] 10) as part of the Biota Investigation in 1993 and 1994 and presented in Technical Memorandum 14 (Blasland, Bouck & Lee, Inc [BBL] 1994). Adult robin tissue PCB data were collected as a part of the MSU studies and are summarized in Blankenship et al. (2005). These data document the presence of PCBs in these tissue types. Thus, earthworms, small mammals and birds are considered secondary exposure media for the Area 1 BERA.

No data specific to Area 1 are available for insects/invertebrates and plants. However, data collected by MSU for the Trowbridge Impoundment indicate the presence of PCBs in the tissues of these two prey types (Blankenship et al. 2005). Because PCBs have been measured in floodplain soil (the primary exposure medium for insects/invertebrates and plants) in the Plainwell Impoundment and the Plainwell No. 2 Dam Area and exposed sediment PCB concentrations are similar to concentrations found in the former Trowbridge Impoundment, it is reasonable to assume PCBs are present in these tissues in Area 1 as well. Thus, insects/invertebrates and plants will be considered secondary exposure media for the Area 1 BERA. Either measured or modeled PCB concentrations in these tissues will be used to estimate dietary exposures to the identified receptors according to the dietary exposure model described in Section 3.4.1. Details regarding how concentrations in prey tissue will be estimated in the Area 1 BERA are provided in Section 3.5.2.

3.2 Exposed Sediment Exposure Depth Interval

Consistent with the CDM Site-Wide BERA (CDM 2003a), for the exposed sediments in the floodplains of the formerly impounded/historically inundated portions of Area 1 (i.e., upstream of the Plainwell Dam and upstream of the Plainwell No. 2 Dam), PCB data for the 0- to 6-inch layer will be used to characterize exposure to ecological receptors. The depth interval to which receptors could be exposed may vary depending on the receptor. The PCB concentration depth profiles were evaluated to identify the appropriate depth interval. As shown in Figures 3-3 and 3-4, in both of the formerly impounded areas within Area 1, the surficial samples (i.e., the

0- to 6-inch interval) for the exposed sediments generally exhibit the highest PCB concentrations. Tables 3-1 and 3-2 list individual sample locations where the PCB concentrations detected at deeper depth intervals are greater than those in the 0- to 6-inch depth interval. As demonstrated by the mean concentrations shown in Figures 3-3 and 3-4, the use of the 0- to12-inch interval in an exposure estimate would result in a lower overall estimate of exposure than that of the 0- to 6-inch depth interval. While the 6- to 12-inch depth interval (or deeper) at a small proportion of the individual locations exhibits the highest PCB concentrations, these exceptions would not result in an under-prediction of exposure on an average basis. Therefore, the 0- to 6-inch depth interval will be used in the Area 1 BERA to estimate potential exposure to PCBs in the surface soils and/or exposed sediments for ecological receptors.

3.3 Exposure Units

The former Plainwell Impoundment occupies approximately 59 acres and the Plainwell No. 2 Dam Area occupies approximately 89 acres. Because these two areas are separated by approximately three river miles, and the floodplain habitat is not contiguous, they will be evaluated as independent areas, or EUs. EUs are defined as the area over which receptors may be exposed to COCs in environmental media. Because the red fox and the red-tailed hawk may forage over areas much larger than either of the two formerly impounded areas, each of these areas will be considered a separate individual EU for these two receptors, and a scenario will be evaluated that includes a foraging range that extends into other adjacent impoundments. For the remaining receptors (i.e., the robin, woodcock, wren, and shrew), which have individual foraging ranges that are smaller than the two formerly impounded areas, the two areas will be sub-divided into smaller EUs. The size and mapping of the EUs will consider the protection of local populations of the identified receptors. The process for identifying receptor-specific EUs will be conducted in cooperation with the USEPA, the State of Michigan, and Federal Natural Resource Trustees before the submittal of the final Area 1 BERA.

3.4 Exposure Models

Three separate approaches will be used to model PCB exposure to terrestrial wildlife. Approach 1 utilizes a standard dietary exposure model to estimate average daily doses based on exposed sediment and tissue ingestion and may be conducted for both total PCBs and TEQs. Approach 2 estimates egg-based exposure by modeling egg tissue concentrations from soil concentrations using a bioaccumulation factor (BAF) and may be conducted for total PCBs and TEQs. Approach 3 estimates egg-based exposure by utilizing a dietary exposure model, similar to that described for Approach 1, to estimate egg tissue concentrations. This approach

will be conducted for TEQs for the American robin only. Each of the three approaches is discussed in detail below and summarized in Figure 3-5.

3.4.1 Approach 1 – Dietary Exposure Model

Dietary exposure in the form of a daily dose will be estimated using methods that are consistent with the CDM Site-Wide BERA (CDM 2003a) and with USEPA (1997a). A daily intake represents an estimate of a constituent dose that a receptor might receive per day and is calculated by summing all intakes for complete and significant exposure pathways (i.e., dietary and incidental soil ingestion) for each wildlife receptor. Consistent with the CDM Site-Wide BERA (CDM 2003a), the dietary dose model that will be employed for the Area 1 BERA follows the form:

Equation 1: $$ADD_{pot} = \sum_{k=1}^{n}(C_k * FR_k * NIR_k) + (NIR_{dw} * PCB_{soil} * DF_{soil}) * SUF$$

Where:

ADD_{pot} = Potential average daily dose (milligrams [mg] PCB/kg body weight [BW]-day [d])

C_k = 95 percent upper confidence limit (95 UCL) PCB concentration in the k^{th} food type (milligrams per kilogram [mg/kg], wet weight [ww])

FR_k = Dietary fraction of intake of the k^{th} food type (range 0 to 1.0)

NIR_k = Normalized ingestion rate of the k^{th} food type (ww of prey ingested per day, kg, ww/kg BW-d)

NIR_{dw}= Normalized ingestion rate of soil/sediment (dry weight [dw] of soil/sediment ingested per day, kg, dw/kg BW-d)

PCB_{soil} = 95 UCL PCB concentration in soil/sediment (mg/kg, dw)

DF soil = Dietary fraction of soil/sediment ingested (range 0 to 1.0)

n = Number of contaminated food types

SUF = Site use factor

3.4.1.1 Exposure Parameters

For wildlife receptors, exposure parameters, such as dietary composition, body weights (BW), and ingestion rates, are defined and summarized in Table 3-3. In this section, exposure and intake assumptions are defined on the basis of available literature information and best professional judgment using the following hierarchy:

1. Site-specific Data for the Kalamazoo River
2. Kalamazoo River Baseline Ecological Risk Assessment (CDM Site-Wide BERA; CDM 2003a);
3. USEPA's Ecological Soil Screening Guidance (EcoSSL; USEPA 2005);
4. USEPA's Wildlife Exposure Factor Handbook (USEPA 1993); and
5. Other sources as necessary (e.g., Nagy 2001).

3.4.1.1.1 Body Weight

Body weight values for the American robin and the red fox used in the CDM Site-Wide BERA (CDM 2003a) will be used in the Area 1 BERA. The American woodcock, red-tailed hawk, and northern short-tailed shrew[5] were not evaluated in the CDM Site-Wide BERA (CDM 2003a). The BW values were obtained from USEPA (1993) by determining the average weights for adult males and females. House wren BW information was obtained from individuals collected during the area of concern-specific investigation conducted in the former Trowbridge Impoundment and the Ft. Custer reference area (Neigh et al. 2006).

3.4.1.1.2 Dietary Composition

The composition of the diet (FR_k) for mammals and birds, expressed as a fraction of the total diet, is based on information on the feeding guilds for each of the species. The dietary composition for the American robin is based on Howell (1942) as described in the Terrestrial Ecological Risk Assessment (TERA) for the Sheboygan River (Chapman 1999). The values in this study were selected as more appropriate than the values previously used in the CDM Site-Wide BERA (CDM 2003a) because they more accurately represents the diet of the robin during the breeding season. For the American woodcock, northern short-tailed shrew, and red-tailed hawk (receptors not previously evaluated in CDM's Site-Wide BERA), dietary composition was taken from studies cited in USEPA (1993). Four studies were summarized in USEPA (1993) for

[5] The literature-based body weight and dietary composition for the shrew will be verified to the degree possible using site-specific dietary composition data collected by MSU.

the American woodcock – the study by Krohn (1970), based on spring/summer diet, was selected as the basis for dietary composition. In this study, the proportion diet was calculated considering grit as a large portion of the diet. Because grit is not an energy source for birds and the ingestion rate used in this model does not include grit as a dietary element, the dietary fractions of prey from this study were recalculated as a percent of prey items excluding grit. This approach results in a more conservative estimate of dietary composition. Another study by Sperry (1940) was considered, but because the data were reported as percent volume of stomach contents rather than as wet weight, this study was not used. In addition, two studies conducted during winter months (Stribling and Doerr 1985; Miller and Causey 1985) were summarized by USEPA (1993); however, the woodcock migrates seasonally and is not expected to be present in Area 1 during the winter months. Based on these limitations, these three studies were not considered further. As a result, dietary composition for the American woodcock is based on data presented in Krohn (1970), in which results were presented as percent wet weight of stomach contents, and grit was not considered a dietary item (i.e., grit was not accounted for in the percent diet).

In USEPA (1993), two studies described dietary composition for the northern short-tailed shrew (Whitaker and Ferraro 1963; Hamilton 1941[6]). The values presented in Hamilton (1941) were only provided as frequency of occurrence (as opposed to percent volume) and are therefore not applicable to determining percent dietary composition. No studies were available that presented dietary composition on a wet weight basis. Thus, the values presented in Whitaker and Ferraro (1963), which presented dietary composition on a percent volume basis, were used to develop the shrew dietary composition for the Area 1 BERA. For the purposes of the BERA, the category called “miscellaneous animals” will be assumed to be small mammals. The category called “other” was found to consist primarily of larval insects in the underlying study. Therefore, this portion of the diet was added to the terrestrial invertebrate dietary fraction. Uncertainties associated with using volume-based rather than wet weight-based estimates for dietary composition will be discussed in the uncertainty analysis.

Red-tailed hawk dietary composition of mammals, birds, and reptiles were estimated from three studies summarized by USEPA (1993). Average dietary composition was obtained from values presented in Adamcick et al. (1979), Janes (1984), and Fitch et al. (1946).

For the house wren, the dietary composition is based on data collected in the former Trowbridge Impoundment by MSU and presented in Neigh et al. (2006). This study indicated that the house wren consumes primarily insects and arachnids (Neigh et al. 2006). For the red

[6] The dietary composition in this study was presented as percent frequency of occurrence. These values were normalized to 1 for averaging.

fox[7], dietary composition was taken from USEPA (1993) as the average of values presented for four seasons in Illinois farm and woodlands (Knable 1970 as cited in USEPA 1993). The specific dietary assumptions for each receptor are summarized in Table 3-3.

3.4.1.1.3 Ingestion Rates

Total food ingestion rates (FIRs) for birds and mammals expressed in kg/kg BW-d, ww are based on available literature cited in the Wildlife Exposure Factors Handbook (USEPA 1993) or values presented in the USEPA's EcoSSL document (USEPA 2005). If an appropriate FIR is not available for a receptor, an FIR was calculated as a function of body mass using allometric equations (Nagy 2001). For the robin, the FIR was selected to be consistent with the approach taken for the Sheboygan River TERA (Chapman 1999) and is primarily based on a study conducted by Levy and Karasov (1989). For the red-tailed hawk, a FIR is available from the EcoSSL document will be used. For the American woodcock, northern short-tailed shrew, and red fox, FIRs were derived from empirical data from studies cited in USEPA 1993. No studies were available for the house wren; therefore, the FIR for the wren was derived using the Nagy equation for passerines (Nagy 2001).

Because exposed sediment EPCs will be expressed on a dry weight basis, the FIR for the soil component of each diet (DF_{soil}) is reported on a dry weight basis. Measured dry weight FIRs were not available in USEPA (1993); therefore, dry weight FIRs expressed as kg/kg-d, dw were calculated using allometric equations provided in Nagy (2001).

3.4.1.1.4 Site Use Factor

The site use factor (SUF) for each receptor is defined as the ratio of the foraging range or home range for each receptor to the area of the EU. As an initial evaluation, each receptor will be evaluated as if it forages 100 percent of the time in each EU (i.e., a SUF of 1 will be assumed). If potential risk is indicated under this initial conservative assumption, a more realistic SUF may be developed based on the habitat needs and specific feeding habits of each receptor. For wide ranging receptors such as the hawk and the fox that may forage over much larger areas than a single impoundment, an alternative scenario will be evaluated that includes a realistic foraging range that may include areas within other adjacent impoundments.

[7] Note the red fox dietary assumptions were revised because the values presented by CDM (2003a) could not be duplicated.

3.4.2 Approach 2 – Egg-Based Exposure Model

At the request of USEPA, an egg-based evaluation will be conducted for robins, woodcocks and house wrens. The U.S. Fish and Wildlife Service (USFWS) has collected robin eggs from 10 locations within the former Plainwell Impoundment; however, these data are not available at this time. When available, these data will be reviewed and considered for inclusion in the Area 1 BERA. Depending on the outcome of this review, additional data may be collected to supplement these data. The available data (which may include USFWS data and/or additional data) would either be used directly to calculate an egg-based EPC, or the soil and egg data would be used together to develop BAFs for modeling egg concentrations. As described in the EPC discussion (Section 3.5.3), this model will apply a total PCB soil to egg BAF to the total PCB exposed sediment EPC for each EU to estimate a total PCB egg EPC. For TEQ analysis, measured egg TEQ concentrations can be used directly or modeled by applying an egg-specific total PCB to TEQ conversion factor (CF) (Figure 3-5) to the modeled total PCB estimates. The development of the egg CF is described in Section 3.5.3.

3.4.3 Approach 3 – Egg-Based Exposure Model via Dietary Ingestion

American robin egg tissue TEQ concentrations will be modeled in Approach 3 using a three-step approach outlined in Chapman and Stapinski (2008). This approach will model total PCB prey tissue concentrations from soil using the BAFs described for prey tissue in Section 3.5.2. Then, an egg concentration will be modeled from this dietary estimate based on relationships between prey type and eggs (i.e., a biomagnification factor) derived from the available data (Figure 3-5). Subsequently, this modeled egg total PCB concentration would be converted to a TEQ concentration using the same CF as described for Approach 2. While this approach adds uncertainty due to the comparative number of modeled variables, it is being included at the request of the USEPA to address concerns regarding potential uncertainty associated with spatially relating soil concentrations directly to bird egg concentrations.

3.5 Exposure Point Concentrations

The Area 1 BERA will utilize EPCs developed from those data that are representative of current conditions. CDM (2003a) incorporated Site-specific floodplain soil and biotic tissue (i.e., small mammal, earthworm, and plant) PCB data collected in 1993. Additional Site-wide and Area-specific data—including both the data that have been collected since 1993 and other new data that may be collected as part of the SRI/FS process—will be evaluated and incorporated in the Area 1 BERA as appropriate and as approved for use by USEPA. The approach for development of EPCs will be established in consultation with a technical work

group comprised of representatives from USEPA, the State of Michigan, and the Federal Natural Resource Trustees.

3.5.1 Exposed Sediments

The dataset for each terrestrial EU will be evaluated and the appropriate non-spatial or spatial weighting approach for EPC calculations will be identified based on the underlying characteristics of the dataset using the approach defined by a technical work group, as described above. Exposed sediment data are available for total PCBs only. If dietary TEQ analyses are conducted, it will be necessary to estimate a TEQ soil concentration for the incidental soil ingestion portion of the diet (see exposure models described in Section 3.4.1). Thus, soil TEQs for each EU will be estimated by applying a total PCB to TEQ CF to the total PCB EPCs. The CF represents a ratio between the total PCB concentration in a sample and the TEQ concentration in that same sample. The CF will be developed based on the available paired total PCB and TEQ data. This may include data collected to supplement available data (as described in Section 3.4.2), and data collected in the former Trowbridge Impoundment by MSU (if additional data are not available, the MSU dataset would be used on its own). Figure 3-5 provides an overview of the process for modeling TEQ concentrations in each exposure media.

3.5.2 Prey Tissue

To estimate dietary exposure for each upper trophic level receptor (Section 3.4.1), estimates of total PCB and possibly TEQ concentrations in prey tissue (C_k from Equation 1) will be required for the food chain evaluation. Prey tissue estimates will include terrestrial plants, earthworms, terrestrial insects/ invertebrates, small mammals, and adult birds. Because the dataset available for each tissue type is relatively small for Area 1 and is limited to data collected in the former Plainwell Impoundment, total PCB tissue estimates will be modeled using regression analysis or BAFs as described below. Additional discussion of the specific data available for Area 1 is provided in Section 6.

The BAF represents the relationship between the soil and the measured prey tissue concentration. It is expressed either as a function based on regression analysis of soil concentrations and biotic tissue concentrations, or as a simple ratio. For example:

Equation 2:
$$BAF = \frac{C_{worm}(\text{mg/kg - wet weight})}{PCB_{soil}(\text{mg/kg dry weight})}$$

Thus,

$$C_{worm} = BAF_{worm} \times PCB_{soil}$$

For worms (depurated), terrestrial invertebrates, and small mammals, a regression of tissue and soil PCB concentrations will be developed based on the available data, which may include data collected in support of the Area 1 BERA, co-located data from the Biota Investigation (BBL 1994), and/or data collected by MSU. If the relationship between soil and tissue is statistically significant, the corresponding regression equation will be used to predict tissue concentrations based on soil concentrations in Area 1. If a significant relationship is not observed, a simple ratio from the Area-specific collocated data will be used. The available worm, terrestrial invertebrate, and small mammal data for Area 1 are described in more detail in Section 6.

For plants, the BAF value used in the CDM Site-Wide BERA (CDM 2003a) based on tomatoes collected from a garden plot in the Trowbridge Impoundment will be used.

In the absence of a significant relationship between soil concentrations and adult bird tissues, a soil-to-bird BAF will be estimated as a simple ratio. Depending on the underlying soil and tissue data distributions, the mean, median, or 95 UCL of each dataset will be used to calculate a ratio. This ratio will be based on the soil and house wren adult tissue data available for the former Trowbridge Impoundment. The house wren is an insectivorous bird that is known to have been feeding within the floodplain. Therefore it represents a measured Site-specific floodplain exposure. In addition, it is considered an appropriate representative for this element of the foodchain for upper trophic level receptors (i.e., the fox and hawk) because upper trophic level receptors would likely feed on a combination of herbivorous, omnivorous, insectivorous, and vermivorous species and the insectivore would represent the high end of the range of possible prey exposure. To address uncertainties associated with this element of the foodchain, an alternative estimate of bird tissue concentrations will be made using a soil to prey BAF in conjunction with a prey to adult tissue BAF. Both scenarios will be presented in the BERA.

The BAFs used to model total PCB tissue concentrations within Area 1 will be based on total PCB concentrations calculated from congener data, but they will be applied to total PCB soil concentrations calculated from Aroclor data. While this adds to the uncertainty of this analysis, this approach was agreed upon based on discussions with USEPA. This and other uncertainty associated with the use of modeled total PCB and TEQ estimates in Area 1 will be discussed in the Uncertainty Analysis.

Because a dietary TEQ-based evaluation of risk may also be conducted for birds (i.e., the robin, woodcock, and house wren) and/or vermivorous mammals (i.e., the shrew)[8], it may be

[8] The implementation of a dietary TEQ-based evaluation for birds or mammals will be dependent on the availability of sufficient toxicity data to develop acceptable TRVs. This will be determined during the TRV development process in cooperation with USEPA, the State of Michigan and the Federal Natural Resource Trustees.

necessary to develop a TEQ EPC for worms, soil invertebrates, and plants. To estimate TEQs for these tissues, a total PCB to TEQ CF will be developed for each tissue type and applied to the modeled total PCB EPC for each EU. The process for developing the CF is the same as that described in Section 3.5.1 for exposed sediments. Figure 3-5 provides an overview of the process for modeling TEQ concentrations in each exposure media.

3.5.3 Egg Tissue

As described in Sections 3.4.2 and 3.4.3, an avian egg-based evaluation will be conducted in addition to the dietary exposure evaluation. No egg data specific to Area 1 are currently available; however, USFWS collected data between 2002 and 2005. These data will be reviewed when available and considered for use in the BERA.

For the egg-based evaluation for robins, woodcocks, and house wrens, total PCB egg EPCs will be modeled using two different approaches (Approach 2 – Section 3.4.2 and Approach 3 – Section 3.4.3). In Approach 2, the BAF will be developed based on available data, which may include the USFWS robin egg data, the MSU soil and house wren total PCB egg datasets for the former Trowbridge Impoundment, and/or additional supplemental data. The house wren MSU dataset was selected as the most appropriate for this application because for this species, MSU found that exposure was almost exclusively from terrestrial prey. The total PCB BAF will then be applied to the total PCB exposed sediment EPC for each EU to calculate an egg total PCB EPC. For the egg-based TEQ evaluation, the total PCB EPC will be converted to a TEQ concentration by applying an egg-specific total PCB to TEQ CF[9]. This CF will also be based on the MSU house wren egg dataset for total PCBs and TEQs for the former Trowbridge Impoundment, and will be developed as described above in Section 3.5.1 for exposed sediments.

For Approach 3, egg concentrations would be modeled using the available dataset (as described above) following the approach outlined in Section 3.4.3. The modeled soil invertebrate and plant tissue concentrations described in Section 3.5.2 would be used along with a diet to egg biomagnification factor to derive a total PCB egg concentration. Subsequently, this modeled egg total PCB concentration would be converted to a TEQ concentration using the same CF as described above for Approach 2.

[9] Note that an additional egg modeling approach will be included at the request of USEPA as described in Section 3.4.3. The egg total PCB concentration will be modeled using a food web based approach, but the TEQ conversion will be conducted in the same way as described here.

4. Effects Assessment

The effects assessment includes identification and development of TRVs representing conservative threshold concentrations or doses for adverse effects for each ecological receptor.

For both birds and mammals, dietary TRVs, and for birds, egg-based TRVs, will be developed in consultation with USEPA, the State of Michigan, and the Federal Natural Resource Trustees. The decision regarding whether both total PCB and TEQ TRVs will be developed will be based on review of the available toxicity datasets. As in the CDM Site-Wide BERA (CDM 2003a), for the Area 1 BERA, both low and high TRVs will be developed. The low TRV is generally a dose at or below which no adverse health effects to the indicator species are expected, even if exposure occurs over an extended duration. It is typically based on a no observed adverse effects level (NOAEL) or equivalent value. The high TRV is the level at which effects may begin to be seen and is typically based on a lowest observed adverse effects level (LOAEL) or equivalent. The true toxicity threshold lies somewhere between the low and high TRVs. This section describes the process that will be employed to derive TRVs that will be used for the protection of terrestrial ecological receptors for Area 1.

Tables 4-1 and 4-2 provide lists of available literature that will be considered and/or reviewed and as part of the total PCB dietary TRV derivation process for birds and mammals, respectively. A list of the studies that will be considered for egg-based TEQ TRV development is provided in Table 4-3. In addition, a list of studies that may be considered for mammalian dietary TEQ-based TRV development is provided in Table 4-4. These tables should be considered a preliminary list and additional studies, if identified during the TRV development process, may also be included in this review. Applicability of the available literature will be assessed primarily according to the following specific criteria:

- relatedness of test species to selected representative species,
- chronic duration of exposure including sensitive life stages,
- measurement of ecologically relevant endpoint, and
- minimal impact of co-contaminants.

Specifically, in evaluating the relatedness of the test species in each study, recent published research regarding the molecular basis of avian species sensitivity to PCBs (Head et al. 2008; Karchner et al. 2006; and Hahn et al. 2006) will be considered. Continuing research conducted

by MSU, the University of Ottawa, and others regarding the mechanism of dioxin-like toxicity and species sensitivity for a wide range of avian species, including several that are present at the Site, will also be considered as appropriate and available. Following review of available information from recent applicable research and the available toxicity literature, studies that satisfy the criteria and that are relevant for potential use as a TRV will be summarized in a matrix. The rationale for the exclusion of studies that are not considered will be documented. TRVs for birds and mammals will be selected using appropriate methods identified in the literature and in collaboration with USEPA, the State of Michigan, and the Federal Natural Resource Trustees.

5. Risk Characterization

Consistent with USEPA guidance (USEPA 1997a, 1998, 1999) and the RA Framework (ARCADIS 2008), the risk characterization for the Area 1 BERA will be based on a weight of evidence approach. The relative strengths and weaknesses and associated uncertainties for each line of evidence will be considered in making final risk conclusions. The Risk Characterization phase consists of the presentation of HQs and other lines of evidence, a Risk Description, Uncertainty Analysis, Risk Conclusions, and RMC Development. The HQs integrate the exposure estimates and effects data to quantitatively evaluate the potential for adverse ecological effects in the identified receptors. The risk description provides an interpretation of the HQs in the context of all available lines of evidence. The uncertainty analysis provides a discussion of the specific uncertainties associated with each line of evidence, and the risk conclusions provide an overall interpretation of risk for each AE based on interpretation of the strengths and weaknesses of each line of evidence. RMCs will be developed as appropriate based on the risk conclusions.

5.1 Hazard Quotients

HQs will be estimated for PCBs for each applicable indicator receptor identified in the Problem Formulation (Section 2) as a line of evidence. HQs are the unitless ratios derived by dividing the receptor's exposure dose by the receptor-specific TRV as follows:

Equation 3:

$$HQ = \frac{\text{Exposure}}{\text{TRV}}$$

Where:

HQ = hazard quotient

Exposure = potential average daily dose (mg PCB/kg BW-d) or egg concentration (mg PCB/kg egg)

TRV = dietary TRV (mg PCB/kg BW-d) for wildlife exposed to soil and prey or egg-based TRV (mg/kg egg)

A range of risk or HQs will be evaluated for wildlife receptors based on low (NOAEL) and high (LOAEL) TRVs and, as described previously, will be based on dietary exposure to total PCBs for birds and mammals and egg-based exposure to TEQs for birds only.

5.2 Risk Description

This section describes the likelihood that COCs could potentially cause adverse effects to terrestrial ecological receptors in Area 1 based on the risk estimates (i.e., for receptors with HQs greater than 1). Because the HQ calculations involve compounded conservative assumptions, when a receptor's low TRV (i.e., NOAEL or equivalent)-based HQ values are less than or equal to 1, there is a low likelihood of adverse effects and no further evaluation is warranted. When low TRV-based HQs are greater than 1, risk is possible and both the low and high TRV (i.e., LOAEL or equivalent)-based HQs and their associated uncertainties should be evaluated with other available lines of evidence and supporting information.

As described for MEs in Section 2.4, dietary HQs for total PCBs are one line of evidence for all receptors evaluated. TEQ-based dietary HQs may also be calculated depending on the availability of acceptable TRVs. For birds, HQs based on egg total PCBs and/or TEQs will be calculated as another line of evidence[10]. For the insectivorous birds, a second line of evidence based on the MSU house wren study conducted in the Trowbridge Impoundment will be incorporated. This study indicated that the house wren forages primarily on terrestrial insects and invertebrates and is therefore an appropriate endpoint for evaluation of the floodplain. Uncertainties associated with this study, including those raised by the Peer Review Panel, will be discussed in Section 5.3.

Other supporting lines of evidence that will be incorporated for evaluation of potential risk include but may not be limited to results of other field studies conducted by MSU in the former Trowbridge Impoundment, studies for other PCB river systems (e.g., Housatonic River robin [Henning et al. 2003] and shrew [Boonstra and Bowman 2003] studies) which are incorporated into a USEPA approved BERA, and the recently developed data regarding the molecular basis for the wide variation in avian sensitivity to the effects of PCBs (e.g. Hahn et al. 2006). Any interpretation of studies conducted at other sites would include a comparison of the relative potency of the PCB mixture to the Site and discussion of other similarities and differences.

[10] The determination of whether total PCB and TEQ-based HQs will be calculated will be based on the outcome of the cooperative TRV development process with USEPA, MDEQ and USFWS.

5.3 Uncertainty Analysis

Uncertainty is inherent in many aspects of the risk assessment process. All risk assessments involve the use of assumptions, judgments, and incomplete data to varying degrees that may contribute to the uncertainty associated with the final risk estimates. Uncertainties may result from both the use of assumptions or models in lieu of actual data and from the error inherent in the estimation of exposure parameters. These uncertainties may result in the potential over- or underestimation of risks. However, because direct measurements are not available for many of the components upon which the risk estimates depend, conservative assumptions and methodologies are generally employed to minimize the possibility of underestimating risk.

Consideration of the uncertainty associated with the components of the risk assessment process allows for a more meaningful interpretation of the results and a better understanding of the potential for adverse effects on ecological communities and receptors. Some of the major potential uncertainties and the effects of these uncertainties on the risk estimates are discussed in this section. Uncertainties associated with estimating risk to ecological receptors will be discussed in the Area 1 BERA such as:

Exposure Assessment

- AEs are based on the protection of receptors at the population or community level of organization, consistent with USEPA (1999) guidance. The local population of receptors will occupy all contiguous habitats and in many cases the portion of the specific habitat onsite represents a small portion of the actual local population range and/or a small portion of population range needed to support a population. Thus, assuming an SUF of 1 (i.e., the area of exposure is limited to the habitat onsite or area of investigation) for exposure via each of the significant exposure pathways is a conservative assumption and likely to result in an overestimate of potential population-level effects.

- Use of literature-derived exposure parameters and allometric models instead of Area-specific parameters.

- Delineation of EUs based on generic receptor and habitat assumptions.

- Uncertainty associated with bioaccumulation and bioavailability calculations.

Effects Assessment

- Development of TRVs (e.g., uncertainty factors, use of laboratory tests).

- Uncertainty associated with extrapolating to sustainability of local populations from studies based on effects to individuals.

- Uncertainty associated with avian and mammalian Toxicity Equivalency Factors used to conduct TEQ analysis.

Risk Characterization

- Reliance on HQs calculated using non-site specific exposure assumptions.

- Interpretation of field studies conducted in downstream areas of the area of concern or at other PCB sites.

- Interpretation of other lines of evidence/applicability to Area 1.

5.4 Risk Conclusions

This section will provide an integrated interpretation of all lines of evidence for each receptor and the key uncertainties. Lines of evidence (LOE) will not be weighted quantitatively. Rather, a detailed description of rationale for the qualitative weight given to each LOE will be provided. For example, a Site-specific LOE might be given a higher weight. However, if that LOE has a high level of associated uncertainty, the weight would be reduced. The relative qualitative weight of each LOE will be used to develop an overall risk conclusion for each AE. When there is agreement between multiple LOEs, the confidence in the overall risk conclusions will be higher.

5.5 RMC Development

Based on the complete interpretation of all appropriate lines of evidence and the uncertainties, RMCs will be developed for the receptors for which potential risk is indicated. For these receptors, a range of RMCs based on varying exposure assumptions and a range of TRVs will be calculated to provide risk managers information to support risk management decisions. RMC calculation based on dietary exposure uses the HQ equation shown in Section 5.1 and sets the HQ equal to 1. In other words, the dose, calculated using the dose equation shown in Section 3.4.1 (Equation 1) with the BAF equation (Equation 2) substituted for C_k, is set equal to the TRV. The equation is then rearranged to solve for C_{soil} and follows the form:

Equation 4:

$$RMC \text{ or } C_{soil} = TRV \div \sum_{k=1}^{n} (BAF_k * FR_k * NIR_k) + (NIR_{dw} * DF_{soil}) * SUF$$

Where:

RMC = Risk-based media concentration

C_{soil} = PCB concentration in soil when HQ = 1

BAF_k = Bioaccumulation factor for the k^{th} food type

FR_k = Dietary fraction of intake of the k^{th} food type (range 0 to 1.0)

NIR_k = Normalized ingestion rate of the k^{th} food type (ww of prey ingested per day, kg, ww/kg BW-d)

NIR_{dw}= Normalized ingestion rate of soil/sediment (dry weight [dw] of soil/sediment ingested per day, kg, dw/kg BW-d)

DF soil = Dietary fraction of soil/sediment ingested (range 0 to 1.0)

n = Number of contaminated food types

SUF = Site use factor

RMCs can also be similarly calculated based on the egg evaluation by substituting C_{egg} for the dietary dose expression above and replacing C_{egg} with BAF_{egg} x PCB_{soil}. As with the dietary prey-tissue and egg tissue EPCs described in Sections 3.5.2 and 3.5.3 respectively, if TEQ-based calculations are conducted, the extrapolation between total PCB and TEQ will be done at the tissue level and then total PCB BAFs will be used to relate the tissue to soil.

6. Available Data and Data Quality Considerations

As discussed previously, the Area 1 BERA will evaluate dietary exposure for terrestrial birds and mammals[11] as well as egg-based exposure for birds. The following subsections describe the available data for Area 1 and the degree to which these data meet the DQOs and data needs for the risk assessments.

Consistent with USEPA guidance, the DQO process is used to ensure that the environmental data used for the risk assessments will be of adequate quantity and quality to support defensible remedial decision-making. As such, DQOs have been developed to ensure that the data needs identified for the Area 1 BERA are addressed. The DQOs are summarized in Table 6-1.

Considering the data needs identified through the Problem Formulation (Section 2) and reflected in the DQOs provided in Table 6-1, the historical data were reviewed to determine their adequacy for conducting the Area 1 BERA. Available data for formerly impounded exposed sediment and terrestrial biota for Area 1 (as summarized in Table 6-2) will be considered for the Area 1 BERA. Data collected, analyzed, and validated according to USEPA-approved sampling plans, standard operating procedures, and Quality Assurance Project Plans, are considered to be of adequate quality for potential inclusion in the risk assessment dataset. Data that were reviewed and recommended for use by the Ecological Risk Studies Peer Review (Dickson et al. 2008) are also considered to be of adequate quality for potential use in the Area 1 BERA. Historical data and data collected for purposes not specifically related to the remedial investigation and risk assessments will be reviewed for representativeness, consistency with other sampling programs, and utility for potential use in the risk assessments. Data usability will be consistent with USEPA's data usability determination (USEPA 2009), per the AOC and SOW.

6.1 Exposed Sediment Data from the Formerly Impounded Areas

As described above, the former Plainwell Impoundment and the Plainwell No. 2 Dam Area are the two distinct sub-areas within Area 1 that will be evaluated in the Area 1 BERA. For these two areas, data that have been collected for remedial investigation and risk assessment support purposes from the exposed sediment areas include:

[11] A dietary TEQ analysis may be conducted for birds and small mammals depending on the availability of adequate toxicity data. Because all currently available data for Area 1 are for total PCB measured as Aroclors, TEQ concentrations in each relevant prey tissue would be modeled as described in Section 3.5.

- 1993 Pre-RI Sampling
- 1993/1994 RI Former Impoundment Investigation
- 1993 RI Floodplain Soil Investigation
- 1993 TBSA Soil Sampling
- 2000 Focused Soil Sampling
- 2001 USEPA Removal Assessment Sampling
- Plainwell No 2 Dam Area SRI/FS Sampling in 2007 and 2008 as part of the Area 1 SRI
- 2007/2008 SRI Bank Soil Sampling

Confirmation samples and other post-removal samples have also been collected as a part of the Plainwell Dam TCRA. These data were collected to document the effectiveness of the removal actions and represent post-removal conditions in the Plainwell Dam Area. In addition to the confirmation sampling, MDEQ collected post-TCRA monitoring samples in the Plainwell Dam Area in October 2008 and samples in the Plainwell No. 2 Dam Area in December 2008. These data will be reviewed according to the considerations described previously in Section 4, to determine how to incorporate or appropriately weight these data in the risk assessments.

The 1993/1994 RI, 2000 Focused Soil Sampling, the 2001 USEPA data, and the 2007/2008 SRI/FS data were collected from discrete sample locations at various depths, including the 0- to 6-inch depth interval. The TBSA[12] data were collected as soil composites of the specified sampling grid. Since the collection of these data sets within the former Plainwell Impoundment, the TCRA has been implemented in this area. Those data collected from within the TCRA removal footprint (i.e., those sediments that have now been removed) will be excluded from the risk assessment dataset. As a part of the TCRA, post-removal confirmation samples were collected as composites over specified grid areas to confirm that the removal actions met performance criteria. The combined spatial coverage of the pre-removal data outside of removal areas and the post-removal data within removal areas is considered adequate for the risk assessments including potential use of spatial interpolation techniques.

[12] The TBSA data were collected from a 0- to 12-inch depth interval, while all other data differentiates the top 6 inches. These data will be incorporated along with the data from the top 6 inches to estimate EPCs.

The Plainwell No 2 Dam Area soil data (with exception of top-of-bank soil samples) were collected at discrete sample locations using an unaligned regular grid design at various depth intervals including the top 6 inches. The spatial coverage of these data is considered adequate for the Area 1 BERA including potential use of spatial interpolation techniques. Remedial work is currently underway in the Plainwell No 2 Dam Area. Data points currently in the dataset for areas to be removed will be excluded from the risk assessment dataset[13]. Likewise, any applicable confirmation data that are available prior to completion of the risk assessment will be incorporated as appropriate.

6.2 Biota Data

Based on the range of ecological receptors identified, PCB data in biotic tissues for plants, earthworms, terrestrial insects/invertebrates, small mammals, birds, and bird eggs are relevant. For Area 1, biotic tissue data are available for earthworms, small mammals, and adult birds. Each of these datasets is described below.

6.2.1 Earthworms

Depurated earthworm data have been collected in Area 1 as a part of the Biota Investigation conducted to support the risk assessment work for the RI. These worms were collected from TBSA 10 along with the TBSA exposed sediment data described above. The complete results were presented in Technical Memorandum 14 (BBL 1994). Three composited earthworm samples were collected from TBSA 10 within the former Plainwell Impoundment. Because worm eating receptors are indicated to be of potential importance to remedial decisions based on the results of CDM's Site-Wide BERA (CDM 2003a), the adequacy of these data is important. No earthworm data have been collected within the Plainwell No. 2 Dam Area. Thus, the available data for Area 1 are not sufficient for the evaluation of vermivorous receptors.

To address this potential data need, additional depurated worm tissue data may potentially be collected as part of other supplemental sampling. Concentrations of total PCBs will be modeled using a regression analysis or a BAF based on the available data, which may include new supplemental data, the historical co-located data from the Biota Investigation (BBL 1994), and the MSU data collected in the former Trowbridge Impoundment for depurated worms as described in Section 3.5.2. While this approach adds some uncertainty to the evaluation, it provides a means of estimating worm tissue concentrations for total PCBs within each EU

[13] If spatial weighting approaches are used in EPC development, the samples from the removal areas will be included in the EPC development to the extent that the area associated with them based on spatial interpolation falls outside of the TCRA removal area.

without having to collect worm tissue in each location. If TEQ tissue estimates are required (based on the outcome of the TRV development process), the TEQ concentrations will be modeled from the total PCB estimates as described in Section 3.5.2.

6.2.2 Small Mammal Data

Small mammal data have been collected in Area 1 as a part of the Biota Investigation conducted to support the risk assessment work for the RI. The full results were presented in Technical Memorandum 14 (BBL 1994). Ten samples of mice were collected from TBSA 10 within the former Plainwell Impoundment. No small mammal data have been collected within the Plainwell No. 2 Dam Area. Due to Agency comments regarding the representativeness of the range of PCB soil concentrations in the TBSA where small mammal tissues were collected, the small mammal dataset is not considered sufficient for the Area 1 BERA.

To address this potential data need, small mammal tissue concentrations for total PCBs will be modeled using a regression analysis or a BAF based on the historical BBL data and the MSU data collected in the former Trowbridge Impoundment as described in Section 3.5.2. While this approach adds some uncertainty to the evaluation, it provides an estimate of small mammal tissue concentrations for total PCBs without the time and expense of additional sampling. Thus, collection of additional small mammal data is not recommended for Area 1 at this time. Additional data collection may be recommended in the future to address uncertainties associated with this modeled approach.

6.2.3 Adult Bird Data

Ten adult robins were collected within the former Plainwell Impoundment by MSU. These data were collected from various areas within the former Plainwell Impoundment and represent a site-specific exposure to birds found within Area 1. However, based on Agency comments regarding where the robins were feeding (i.e., may have been feeding both on and off site), the bird tissue dataset is not considered sufficient for the Area 1 BERA.

To address this potential data need, bird tissue concentrations for total PCBs will be modeled using two approaches as described in Section 3.5.2. One approach includes use of a soil to adult tissue BAF based on the MSU house wren data collected in the former Trowbridge Impoundment. The second approach includes use of a soil to prey BAF in combination with a prey to adult tissue BAF. While these modeled approaches add some uncertainty to the evaluation, they will provide an estimate of bird tissue concentrations for total PCBs within each EU without having to collect additional bird tissue data in each location.

6.2.4 Plants

No Area 1-specific data are available for plants. Because plant tissue estimates will be needed for the Area 1 BERA, plant tissue estimates will be modeled for total PCBs and/or TEQs as described in Section 3.5.2 using the BAF included in the CDM BERA (2003a). Thus, no additional plant tissue will be required. While this approach adds some uncertainty to the evaluation, it provides an estimate of plant tissue concentrations without the time and expense of additional sampling. Thus, collection of additional plant tissue data is not recommended for Area 1 at this time. Additional data collection may be recommended in the future to address uncertainties associated with this modeled approach.

6.2.5 Terrestrial Invertebrates/Insects

For terrestrial invertebrates (non-worms), no Area-1 specific data are currently available. To address this potential data need supplemental data may be collected. Concentrations of total PCBs will be modeled using a regression analysis or a BAF based on available data, which may include the MSU data collected in the former Trowbridge Impoundment either alone or in conjunction with supplemental data. While this modeling approach adds some uncertainty to the evaluation, it provides a means of estimating invertebrate tissue concentrations for total PCBs within each EU without having to collect tissue in each location.

6.2.6 Bird Eggs

The USFWS has collected Area 1-specific robin eggs from approximately 10 nests within the former Plainwell Impoundment over the course of several years (all pre-remediation). These data are not available at this time, but will be reviewed and considered for use in the BERA. . Because an egg-based evaluation will be conducted, it will be necessary to estimate TEQ and possibly total PCB concentrations in eggs for each EU within Area 1.

Supplemental bird egg data may also be collected. The focus of the sampling effort would be to identify robin nests that are situated within the floodplain such that the majority of the foraging range of the nesting pair would be contained within the floodplain. An egg would be sampled from each nest, along with soil from sample locations within an appropriately sized foraging area around the nest. Earthworm and other soil invertebrates may also be collected from these areas. The available egg data would either be used directly to calculate an egg-based EPC, or the soil, egg, and invertebrate data would be used together to develop BAFs for modeling egg concentrations. Section 3.5.3 describes the approaches that may be used to develop TEQ and total PCB egg EPCs. In the absence of additional supplemental data, egg concentrations will be estimated using existing data, and/or modeled as described in Section 3.5.3 using existing available data. If new data are collected, the sampling effort would be conducted in spring of 2010 and a supplemental FSP would be submitted to USEPA for approval.

7. References

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Tables

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Table 3-1 -- Plainwell No. 2 Dam Area Floodplain Soil PCB Concentration vs. Depth Analysis

Sample ID	PCB Concentration (mg/kg) by Depth Interval				Average PCB Concentration in 0-6 and 6-12 inch Depth Intervals (mg/kg)
	0 - 6 inches	6 - 12 inches	12 - 24 inches	24+ inches	
FF-44	**6.96**	1.47	0.084		4.2
FF-45	**0.12**	0.11	0.11		0.12
FF-47	**5.85**	0.303			3.1
FF-48	**14.54**	2.27	0.097		8.4
FF-49	0.369	0.69	0.065		0.53
FF-50	0.126	0.297	*18.3*		0.21
KRT11-TB-A	**1.02**	0.047	0.082		0.53
KRT11-TB-B	**0.853**	0.601	0.338		0.73
KRT12-TB-A	8.39	*16.6*	2.95		12
KRT12-TB-B	2.54	*3.74*	0.74		3.1
KRT14-TB-A	**0.059**	0.056	0.056	0.058	0.058
KRT14-TB-B	**0.059**	0.053	0.054		0.056
P2BN-01	0.052	0.054	0.054		0.053
P2BN-02	**0.055**	0.053	0.054		0.054
P2BN-03	0.041	0.109	0.074		0.075
P2BN-04	**0.055**	0.054			0.055
P2BN-05	0.05	0.069	0.067	0.088	0.060
P2BN-06	0.053	0.054	0.053		0.054
P2BN-07	**1.45**	0.11			0.78
P2BN-08	**2.58**	0.468	0.038		1.5
P2BN-09	**1.15**	0.37	0.09		0.76
P2BN-10	**31**	11.7	0.1495		21
P2BN-11	**3.45**	0.14	0.12		1.8
P2BN-12	**1.56**	0.13	0.115		0.85
P2BN-13	**0.3**	0.13	0.11		0.22
P2BN-14	**1.13**	0.083	0.1		0.61
P2BN-15	**1.65**	1.2	0.11		1.4
P2BN-16	**0.87**	0.17	0.12		0.52
P2BN-17	**3.38**	0.097	0.105		1.7
P2BN-18	**0.945**	0.091	0.043		0.52
P2BN-19	**2.87**	0.568	0.062		1.7
P2BN-20	**6**	2.65	0.075		4.3
P2BN-21	**1.76**	0.178	0.1	0.088	0.97
P2BN-22	**5.94**	0.14	0.15		3.0
P2BN-23	**0.88**	0.274	0.064		0.58
P2BN-24	**1.06**	0.459	0.128		0.76
P2BN-25	**0.719**	0.092	0.072	0.083	0.41
P2BN-26	7.64	8.42	*44.8*		8.0
P2BN-27	**5.84**	2.12	0.11		4.0
P2BN-28	8.9	*12.78*	0.2475		11
P2BN-29	**2.74**	1.13	0.076		1.9
P2BN-30	**7.01**	6.14	1.25		6.6
P2BN-31	**7.6**	2.5	0.062		5.1
P2BN-32	9.04	*17.8*	0.128		13
P2BN-33	**14.5**	7.9	0.18		11
P2BN-34	10.52	*25.3*	0.13		18
P2BN-35	1.51	0.11	*24.6*		0.81
P2BN-36	3.62	3.83	0.18		3.7
P2BN-37	5.86	*26.8*	0.39		16
P2BN-38	**0.3835**	0.06	0.06		0.22
P2BN-39	**1.01**	0.172			0.59

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Sample ID	PCB Concentration (mg/kg) by Depth Interval				Average PCB Concentration in 0-6 and 6-12 inch Depth Intervals (mg/kg)
	0 - 6 inches	6 - 12 inches	12 - 24 inches	24+ inches	
P2BS-01	0.054	*1.05*	*8.11*		0.55
P2BS-02	**0.056**	0.052	0.053		0.054
P2BS-03	**38**	16.1	1.91		27
P2BS-04	**14.24**	11.79	0.384	0.094	13
P2BS-05	**4.98**	0.11			2.5
P2BS-06	**3.94**	2.92	0.59		3.4
P2BS-07	**0.84**	0.083	0.071		0.46
P2BS-08	**2.26**	1.01	0.1		1.6
P2BS-09	**0.098**	0.08	0.091		0.089
P2BS-10	**19.3**	3.8	0.11		12
P2BS-11	**0.7**	0.35	0.1		0.53
P2BS-12	**6.94**	0.674	0.073		3.8
P2BS-13	1.5	*3.06*	0.13		2.3
P2BS-14	**0.069**	0.067	0.064		0.068
P2BS-15	0.068	0.077	0.062		0.073
P2BS-16	0.068	0.07	0.06		0.069
P2BS-17	**2.69**	0.18	0.125		1.4
P2BS-18	**0.71**	0.073	0.08		0.39
P2BS-19	11.36	*23.4*	1.46		17
P2BS-20	**5.83**	4.58	0.11		5.2
P2BS-21	1.17	*4.39*	*41.7*		2.8
P2BS-22	7.71	*9.37*	3.14		8.5
P2BS-23	**2.52**	1.45	0.054		2.0
P2BS-24	**4.08**	0.646	0.08	0.084	2.4
P2BS-25	**29.5**	7.9	0.1		19
P2BS-26	5.56	*7.96*	0.1		6.8
P2BS-27	12.21	*35*	0.116		24
P2BS-28	**2.51**	1.85	0.921		2.2
P2BS-29	**2.54**	0.075	0.084		1.31
P2BS-30	3.67	*10.21*	0.423		6.9
P2BS-31	**0.243**	0.059	0.0765		0.15
P2BS-32	**2.03**	0.16	0.11		1.1
P2BS-33	**1.55**	1.19	0.069		1.4
P2BS-34	**0.2535**	0.24	0.075		0.25
P2BS-35	**12.8**	6.95	0.096		9.9
P2BS-36	**3.57**	2.72	0.1		3.1
P2BS-37	**2.4**	0.197	0.071		1.3
P2BS-38	1.77	*6*	0.31		3.9
P2BS-39	**1.13**	0.183	0.047		0.66
P2FP-001	**18.4**	0.38	0.086		9.4
P2FP-002	**2.93**	0.11	0.064		1.5
P2FP-003	**2.41**	0.4	0.16		1.4
P2FP-004	**9.63**	3	0.095		6.3
P2FP-005	**1.97**	0.41	0.1		1.2
P2FP-006	**0.24**	0.077	0.07		0.16
P2FP-007	**0.53**	0.22	0.15		0.38
P2FP-008	**3.02**	0.11	0.087		1.6
P2FP-009	**1.72**	0.11	0.145		0.92
P2FP-010	0.31	0.0645	*3.23*	*1.29*	0.19
P2FP-011	**0.976**	0.27	0.14		0.62
P2FP-012	**1.172**	0.16	0.077	0.078	0.67

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Table 3-1 -- Plainwell No. 2 Dam Area Floodplain Soil PCB Concentration vs. Depth Analysis

Sample ID	PCB Concentration (mg/kg) by Depth Interval				Average PCB Concentration in 0-6 and 6-12 inch Depth Intervals (mg/kg)
	0 - 6 inches	6 - 12 inches	12 - 24 inches	24+ inches	
P2FP-013	**2.56**	1.29	0.1		1.9
P2FP-014	**0.374**	0.068	0.06	0.057	0.22
P2FP-015	**0.111**	0.054	0.057		0.083
P2FP-016	**5**	1.87	0.129	0.062	3.4
P2FP-017	**1.44**	0.394	0.06		0.92
P2FP-018	**0.404**	0.036	0.063	0.06	0.22
P2FP-019	**6.96**	0.506	0.061	0.062	3.7
P2FP-020	**3.16**	0.072	0.163		1.6
P2FP-021	**5.07**	0.17	0.11		2.6
P2FP-022	**43.8**	0.15	0.15		22
P2FP-023	**0.899**	0.2745	0.081		0.59
P2FP-024	**2.62**	0.639	0.082	0.071	1.6
P2FP-025	**11.7**	0.26	0.11		6.0
P2FP-026	**5.32**	1.18	0.053		3.3
P2FP-027	**4.71**	2.2	0.075		3.5
P2FP-028	**0.41**	0.076	0.074		0.24
P2FP-029	**3.155**	0.091			1.6
P2FP-030	0.17	*5.84*			3.0
P2FP-031	**1.5**	0.7	0.086		1.1
P2FP-032	**0.5**	0.18			0.34
P2FP-033	**0.92**	0.078	0.076		0.50
P2FP-034	**0.55**	0.085	0.0865		0.32
P2FP-035	**5.5**	0.098	0.063		2.8
P2FP-036	**0.94**	0.11	0.086		0.53
P2FP-037	**0.256**	0.059	0.071		0.16
P2FP-038	**11.7**	4.79	0.36		8.2
P2FP-039	**4.56**	1.93	0.08	0.069	3.2
P2FP-040	**1.77**	0.11	0.075	0.063	0.94
P2FP-041	**0.397**	0.067	0.066	0.059	0.23
P2FP-042	**3.38**	0.298	0.15		1.8
P2FP-043	**2.19**	0.11	0.074		1.2
P2FP-044	**2.32**	0.074			1.2
P2FP-045	**1.51**	0.12	0.067		0.82
P2FP-046	**0.68**	0.23	0.094		0.46
P2FP-047	**1.2**	0.082	0.078		0.64
P2FP-048	**0.51**	0.064	0.037		0.29
P2FP-049	**3.03**	0.11	0.081		1.6
P2FP-050	**1.76**	0.23	0.079		1.0
P2FP-051	4.19	*11.06*	1.75	0.075	7.6
P2FP-052	**1.14**	0.11	0.091		0.63
P2FP-053	12.74	*59.9*	0.92		36
P2FP-054	**1.53**	0.078	0.082		0.80
P2FP-055	**0.095**	0.063	0.064		0.079
P2FP-056	**0.49**	0.19	0.13		0.34
P2FP-057	**0.067**	0.061	0.059	0.06	0.064
P2FP-058	**0.556**	0.09	0.13		0.32
P2FP-059	**0.405**	0.098	0.074		0.25
P2FP-060	**0.15**	0.075	0.078		0.11
P2FP-061	**0.22**	0.08	0.073		0.15
P2FP-062	**1.66**	0.658	0.1		1.2
P2FP-063	**2.42**	0.78	0.098		1.6

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Table 3-1 -- Plainwell No. 2 Dam Area Floodplain Soil PCB Concentration vs. Depth Analysis

Sample ID	PCB Concentration (mg/kg) by Depth Interval				Average PCB Concentration in 0-6 and 6-12 inch Depth Intervals (mg/kg)
	0 - 6 inches	6 - 12 inches	12 - 24 inches	24+ inches	
P2FP-064	**0.644**	0.11	0.08		0.38
P2FP-065	**1.74**	0.82	0.1		1.3
P2FP-066	**1.69**	1.009	0.086		1.3
P2FP-067	**2.49**	0.4	0.094		1.4
P2FP-068	**1.12**	0.134	0.071		0.63
P2FP-069	6.02	0.24	*14.1*		3.1
P2FP-070	**1.31**	0.083	0.069		0.70
P2FP-071	**0.18**	0.08	0.072	0.091	0.13
P2FP-072	**0.63**	0.088	0.077		0.36
P2FP-073	**1.06**	0.072	0.066	0.055	0.57
P2FP-074	**0.32**	0.0595	0.062		0.19
P2FP-075	**5.16**	3.29	0.06		4.2
P2FP-076	**0.69**	0.18	0.11		0.44
P2FP-077	4.1	*8.92*	0.17		6.5
P2FP-078	1.121	*4.14*	0.086		2.6
P2FP-079	**2.68**	0.262	0.075	0.077	1.5
P2FP-080	**1.07**	0.328	0.072		0.70
P2FP-081	**0.412**	0.089	0.066		0.25
P2FP-082	**0.768**	0.086	0.073		0.43
P2FP-083	**0.14**	0.093	0.072		0.12
P2FP-084	0.1385	0.156	0.076		0.15
P2FP-085	**0.078**	0.062	0.067	0.05	0.070
P2FP-086	0.031	0.065	0.061		0.048
P2FP-087	**2.32**	0.062	0.1		1.2
P2FP-088	**0.23**	0.075	0.069		0.15
P2FP-089	**0.416**	0.072	0.066		0.24
P2FP-090	**13.8**	4.5	0.051		9.2
P2FP-091	**1.37**	0.753	0.071		1.1
P2FP-092	**0.27**	0.068	0.075		0.17
P2FP-093	**0.413**	0.066	0.07		0.24
P2FP-094	**12.2**	10.04	0.937	0.111	11
P2FP-095	**4.23**	0.265	0.098		2.2

Notes:

1) Bolded values represent sample locations where the maximum detected concentration is within the top 6 inches.
2) Shaded and italicized values represent locations where the detected concentration is greater than that in the top 6 inches, is greater than 1 mg/kg, and is greater than the surface concentration by more than 15 percent.

mg/kg = milligrams per kilogram
PCB = polychlorinated biphenyl

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Table 3-2 -- Plainwell Impoundment Floodplain Soil PCB Concentration vs. Depth Analysis

Sample ID	PCB Concentration (mg/kg) by Depth Interval				Average PCB Concentration in 0-6 and 6-12 inch Depth Intervals (mg/kg)
	0 - 6 inches	6 - 12 inches	12 - 24 inches	24+ inches	
FF-52	9.2	*15.4*	0.673		12
PES1-1	**0.06**				0.06
PES1-5	**3.95**	0.46	0.067		2.2
PES1-6	**32.6**	19.8	11.7	2.28	26
PES1-7	**0.0565**				0.057
PES2-1	**0.057**				0.057
PES2-5	**2**	0.78	0.153	0.13	1.4
PES2-6	3.7	4.1	0.45	0.066	3.9
PES2-7	**0.0635**				0.064
PES3-1	**0.0585**				0.059
PES3-6	**0.71**	0.36	0.433	0.11	0.54
PES3-7	**0.057**				0.057
PES4-1	**0.3**				0.30
PES4-2	**1.58**	0.84	0.11	0.094	1.2
PES4-3	**4.475**	1.73	0.9	0.445	3.1
PES4-4	**1.07**	0.179	0.034		0.62
PES4-5	**10.5**	0.94			5.7
PES4-7	**0.06**				0.06
PES5-1	**0.058**				0.058
PES5-4	2.16	0.73	*4.56*	1.73	1.4
PES5-5	**1.09**	0.52	0.089	0.077	0.81
PES5-6	**2.62**	2.12	0.648	0.238	2.4
PES5-7	**0.06**				0.06
PES6-1	**0.86**				0.86
PES6-4	**8.86**	1.86	7.4	7.88	5.4
PES6-5	**0.89**	0.32	0.088	0.1	0.61
PES6-6	**6.75**	5.42	3.37	6.57	6.1
PES6-7	**0.065**				0.065
SL001	17.8	*79*	*24.4*		48
SL002	5.33	*33.3*	1.37		19
SL003	10.9	*17.2*	0.65	0.189	14
SL004	**0.039**	0.036	0.036		0.038
SL007	0.019	0.011	0.04		0.015
SL009	0.184	0.061	0.198	0.059	0.12
SL011	1.51	*2.63*	*32.43*	*3.86*	2.1
SL012	**12.4**	0.0322	0.55		6.2
SL012-1	**7.6**	0.82	0.65	0.064	4.2
SL012-10	**17.3**	2.56	0.465	0.271	9.9
SL012-14	**0.018**	0.008	0.00257		0.013
SL012-15	**49**	32	7	0.154	41
SL012-16	**12.2**	5.5	0.081	0.107	8.9
SL012-17	**2.17**	1.17	0.111	0.081	1.7
SL012-18	7.87	*31.2*	1.06	1.55	20
SL012-19	**9.9**	1.39	0.238	0.185	5.6
SL012-2	**16**	7.1	0.356	0.344	12
SL012-20	2.81	0.282	*4.54*	0.154	1.5
SL012-21	0.0075	0.01125	0.0066		0.0094
SL012-22	**15**	8	0.361	0.148	12
SL012-24	**6**	0.89	0.373	0.045	3.4
SL012-25	**7.55**	2.07	0.291	0.087	4.8
SL012-3	**28.4**	7.1	0.213	0.31	18

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Table 3-2 -- Plainwell Impoundment Floodplain Soil PCB Concentration vs. Depth Analysis

Sample ID	PCB Concentration (mg/kg) by Depth Interval				Average PCB Concentration in 0-6 and 6-12 inch Depth Intervals (mg/kg)
	0 - 6 inches	6 - 12 inches	12 - 24 inches	24+ inches	
SL012-6	5.6	*19.8*	0.212	0.143	13
SL012-8	**24.5**	5.8	0.45	0.425	15
SL012-9	**5.4**	0.335	0.103	0.215	2.9
SL013	**0.036**	0.034	0.035		0.035
SL015-13	1.17	0.174	*1.4*	0.469	0.67
SL015-14	**22.6**	20.2	16	13.05	21
SL015-16	**43.4**	14.21	11.85	0.389	29
SL015-21	**2.32**	1.79	0.683	1.14	2.1
SL015-22	**30.3**	4.7	2.31	1.12	18
SL015-26	**8.8**	5.6	4.72	1.53	7.2
SL015-27	**9.9**	2.92	0.42	0.875	6.4
SL015-28	0.58	0.214	0.242	0.83	0.40
SL015-29	0.053	0.199	0.113	0.0149	0.13
SL015-30	**1.32**	0.72	0.97	0.509	1.0
SL017	20.7		*26.9*	0.6	21
SL018	0.0069	0.057	0.1895	0.044	0.032
SL019	0.028	0.18125			0.10
SL023	**9.3**	0.569	0.058		4.9
SL024	**1.92**	0.088	0.081	0.043	1.0
SL025	**0.81**	0.266	0.055	0.035	0.54
SL026	**4.45**	3.27			3.9
SL027	**1.087**	0.219	0.049	0.022	0.65
SL028	**46.9**	36	4.8		41
SL029	**38.8**	0.89	0.46	0.266	20
SL029-1	**2.52**	1.12	0.724	0.4615	1.8
SL029-10	**3.5**	1.65	0.68	0.49	2.6
SL029-11	**18**	1.85	1.22	0.509	9.9
SL029-12	**10.1**	1.34	3.1	0.45	5.7
SL029-13	**6.3**	0.214	0.53	0.687	3.3
SL029-14	**21.5**	2.9	2	2.595	12
SL029-15	**2.9**	1.01	0.51	0.3315	2.0
SL029-16	**1.48**	1.01	0.194	0.356	1.2
SL029-17	**37.9**	2.38	1.4	0.805	20
SL029-18	4.38	4.4	0.81	0.451	4.4
SL029-19	0.29	*3.98*	0.9915	0.72	2.1
SL029-2	**13.6**	2.16	1.39	0.251	7.9
SL029-20	**7.5**	2.44	0.511	0.114	5.0
SL029-21	**1.13**	0.194	0.5625	0.066	0.66
SL029-22	**5.05**	0.49	0.307	0.033	2.8
SL029-23	6.8	6.9	1.9	5.6	6.9
SL029-24	**43**	13.1	0.9	3.49	28
SL029-25	2.82	*45.3*	*7.29*	0.555	24
SL029-26	**2.63**	0.82	0.39	0.243	1.7
SL029-27	**0.51**	0.203	0.0955	0.106	0.36
SL029-28	**1.77**	0.94	0.543	0.205	1.4
SL029-29	**37.5**	1.701	0.486	0.45	20
SL029-3	**26.9**	4.38	1.01	1.095	16
SL029-30	1.97	*5.8*	0.67	0.2255	3.9
SL029-31	**7.7**	6.4	0.9	0.97	7.1
SL029-33	**0.036**	0.036	0.035	0.035	0.036
SL029-34	**4.62**	4.27	2.53	0.93	4.4

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Table 3-2 -- Plainwell Impoundment Floodplain Soil PCB Concentration vs. Depth Analysis

Sample ID	PCB Concentration (mg/kg) by Depth Interval				Average PCB Concentration in 0-6 and 6-12 inch Depth Intervals (mg/kg)
	0 - 6 inches	6 - 12 inches	12 - 24 inches	24+ inches	
SL029-4	**5.9**	3.43	3.04	0.385	4.7
SL029-5	**20.9**	5.7	2.54	0.76	13
SL029-6	**9.2**	1.18	0.7	0.212	5.2
SL029-7	**6.98**	1.56	1.4	1.24	4.3
SL029-8	**21.1**	9.8	1.63	0.205	15
SL029-9	**4.38**	2.01	0.503	0.94	3.2
SL030	**5.7**	1.2	0.54		3.5
SL032	**0.73**	0.3	0.072	0.063	0.52
SL034	**28.6**	1.82	4.2	6.79	15
SL035	**0.21**	0.027			0.12
SL036	0.036	0.037	0.035	0.036	0.037
SL037	**2.32**	1.57	0.143	0.068	1.9
SL038	**0.42**	0.303	0.112	0.075	0.36
SL048	0.0034	0.037			0.020

Notes:
1) Bolded values represent sample locations where the maximum detected concentration is within the top 6 inches.
2) Shaded and italicized values represent locations where the detected concentration is greater than that in the top 6 inches, is greater than 1 mg/kg, and is greater than the surface concentration by more than 15 percent.
3) Data are only those data that are remaining post TCRA and do not include MDEQ data or TCRA confirmation data.

MDEQ = Michigan Department of Environmental Quality
mg/kg = milligrams per kilogram
PCB = polychlorinated biphenyl
TCRA = time-critical removal action

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Table 3-3 - Exposure Parameters

Parameter	Terrestrial Vermivorous Bird		Terrestrial Vermivorous Bird		Terrestrial Insectivorous Bird		Terrestrial Carnivorous Bird		Terrestrial Vermivous Mammal		Terrestrial Carnivorous Mammal	
	American Robin		American Woodcock		House Wren		Red-tailed Hawk		Northern Short-tailed Shrew		Red Fox	
	Data	Source	Data	Source	Data	Source	Data	Source	Data	Source	Data	Source
Body Weight (kg)	0.077	USEPA (1993), as cited in CDM (2003)	0.170	USEPA (1993)	0.0104	MSU (average of all male and female adults from Trowbridge and Fort Custer)	1.13	USEPA (1993)	0.0170	USEPA (1993)	4.54	USEPA (1993)
Composition of Diet (fraction)												
Soil/sediment	0.10	USEPA (1993), as cited in CDM (2003)	0.16	USEPA (2005)	0	Soil ingestion is expected to be negligible	0.057	USEPA (2005)	0.030	USEPA (2005)	0.028	Beyer et al. (1994)
Plants	0.13	Howell (1942) as cited in Chapman (1999)	0.000	Sperry 1940	--	--	--	--	0.138	Whitaker and Ferraro 1963	0.17	Knable et al. (1974), as cited in USEPA (1993)
Worms	0.24	Howell (1942) as cited in Chapman (1999)	0.832	Sperry 1940	--	--	--	--	0.314	Whitaker and Ferraro 1963	--	--
Insects/Terrestrial Invertebrates	0.64	Howell (1942) as cited in Chapman (1999)	0.168	Sperry 1940	1	Neigh et al. (2006)	--	--	0.47	Whitaker and Ferraro 1963	0.040	Knable et al. (1974), as cited in USEPA (1993)
Birds	--	--	--	--	--	--	0.12	USEPA (1993) (average of 3 studies)	--	--	0.14	Knable et al. (1974), as cited in USEPA (1993)
Mammals	--	--	--	--	--	--	0.82	USEPA (1993) (average of 3 studies)	0.081	Whitaker and Ferraro 1963	0.65	Knable et al. (1974), as cited in USEPA (1993)
Ingestion Rate												
Food Ingestion Rate (kg/kg-bw-d, ww)	0.38	Levy and Karasov (1989) as cited in Chapman (1999)	0.77	USEPA (1993)	0.97	Nagy (2001), equation 38	0.035	USEPA (2005)	0.62	USEPA (1993)	0.16	USEPA (1993), as cited in CDM (2003)
Soil/Sediment Ingestion Rate (kg/kg-bw-d, dw)	0.16	Nagy (2001), equation 37	0.12	Nagy (2001), equation 59	0.30	Nagy (2001), equation 37	0.079	Nagy (2001), equation 63	0.18	Nagy (2001), equation 11	0.038	Nagy (2001), equation 25

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Table 4-1 -- Literature to be Considered for Total PCB Avian Dietary TRV Development

Barron, M., H. Galbrith and D. Beltman. 1995. Comparative reproductive and developmental toxicology of PCBs in birds. Comp Biochem Physiol 112C(1): 1-14.
Bird, D. M., P. H. Tucker, G. A. Fox, and P. C. Lague, 1983. Synergistic effects of Aroclor 1254 and mirex on the semen characteristics of American kestrels. Archives of Environmental Contamination and Toxicology. 12:633–640.
Briggs, D. and J. Harris. 1973. Polychlorinated biphenyls influence on hatchability. Poultry Sci 52: 1291-1294.
Britton, W. and T. Huston. 1973. Influence of polychlorinated biphenyls in the laying hen. Poultry Sci 52: 1620-1624
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Table 4-1 -- Literature to be Considered for Total PCB Avian Dietary TRV Development

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Table 4-1 -- Literature to be Considered for Total PCB Avian Dietary TRV Development

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Table 4-2 -- Literature to be Considered for Total PCB Mammalian Dietary TRV Development

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Table 4-3 -- Literature to be Considered for Avian Egg-Based Dioxin TEQ TRV Development

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Table 4-3 -- Literature to be Considered for Avian Egg-Based Dioxin TEQ TRV Development

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Table 4-4 -- Literature to be Considered for Possible Mammalian Dietary Dioxin TEQ TRV Development

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Table 4-4 -- Literature to be Considered for Possible Mammalian Dietary Dioxin TEQ TRV Development

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Table 6-1 - Exposed Sediment Data Quality Objectives

STEP 1 State the Problem	STEP 2 Identify the Decisions (Risk Questions and Associated Endpoints)	STEP 3 Identify the Inputs to the Decisions	STEP 4 Define Study Boundaries	STEP 5 Develop Decision Rules	STEP 6 Specify Tolerable Limits on Errors	STEP 7 Describe the Sampling Design
Risk to ecological receptors associated with exposed sediments in the former Plainwell Dam and Plainwell No. 2 Dam areas is unknown	***RQ1:*** Do total PCB and/or TEQ concentrations in floodplain soil and associated biota pose unacceptable ecological risk to local populations of **small vermivorous mammals** (e.g., short-tailed shrew)? **ME1**- Compare modeled dietary total PCB and possibly TEQ[1] exposure to TRVs (calculate HQs).	– Validated soil chemistry (0-6 inches bgs, adequately sensitive detection limits) – Validated prey (i.e., earthworm, soil invertebrate, plant and small mammal) tissue chemistry data from site (adequately sensitive detection limits) or sufficient information to derive a site-specific BAF – Receptor-specific food web model input (exposure) parameters – Total PCB and TEQ-specific mammalian dietary TRVs	– For Area 1, the areas that are considered exposure areas for terrestrial receptors include the formerly impounded areas upstream of the Plainwell Dam and the Plainwell No. 2 Dam. – For some receptors, these exposure areas will be further subdivided into smaller areas based on the receptor foraging ranges. – The evaluation of PCB concentrations in media will be 0 to 6 inches bgs. – No specific temporal study boundaries have been defined; however, the most recent and relevant data will be given priority. Because PCB concentrations within the floodplain are not expected to vary temporally, a seasonal study design component is not warranted.	– If the NOAEL-based HQ <1 assuming a SUF of 1 for both total PCBs and TEQs, then risk to vermivorous birds and mammals is considered to be unlikely. – If the HQs are not in agreement (e.g., total PCB HQ < 1 and TEQ HQ > 1), or both total PCB and TEQ HQs >1, then conduct a more refined spatial evaluation of receptor based on specific habitat requirements. – Use weight of evidence approach to evaluate all lines of evidence and additional supporting information (e.g., potential relevance and significance of other field studies).	– Food web/dietary intake exposure models incorporate many uncertainties which are typically mitigated to a degree through the incorporation of conservatism. Similarly TRVs are generic and incorporate a high degree of conservatism. Thus, the HQs calculated will result in an acceptable level of conservatism and will minimize the chance of false negative findings. – Earthworm tissue concentrations are a critical component of the food web for vermivorous birds and mammals. Three worm tissue samples are available for Area 1 and no congener data to support TEQ analysis are available. These data do not support exposure estimates with an acceptable level of certainty for the BERA. However, these data along with collocated soil and worm data collected by MSU in the former Trowbridge Impoundment can be used to develop a model to estimate worm tissue total PCB and, if needed, TEQ concentrations. – Soil invertebrates are a critical component of the robin, woodcock, house wren, and shrew diet and no site-specific data are available for this tissue type. Collocated soil and invertebrate tissue data collected by MSU in the former Trowbridge Impoundment can be used to develop a model to estimate invertebrate tissue total PCB and, if needed, TEQ concentrations. – Plant tissue concentrations are a component of the shrew, robin and woodcock diet and will be modeled using the BAFs from the CDM BERA (CDM 2003). This uncertainty is considered acceptable because plants are not considered to be a critical exposure media for PCBs to wildlife as uptake of PCBs into plant tissues has been shown to be minimal relative to other dietary components. If needed, TEQs will be modeled using a model developed based on the aforementioned MSU data. – Egg TEQ and possibly total PCB data are required for the egg-based evaluation endpoint for vermivorous and insectivorous birds. No egg data are available for Area 1. However, data collected by MSU in the former Trowbridge Impoundment can be used to develop a model to estimate egg tissue total PCB and TEQ concentrations.	No data collection recommended.
	RQ2: Do total PCB and/or TEQ concentrations in floodplain soils and associated biota pose unacceptable incremental ecological risk to **vermivorous birds** (e.g., American robin, American woodcock)? **ME1**- Compare modeled dietary total PCB and possibly TEQ[1] exposure to TRVs (calculate HQs). **ME2**- Compare modeled egg-based TEQ and possibly total PCB[1] exposure to TRVs (calculate HQs).	– Validated soil chemistry (0-6 inches bgs, adequately sensitive detection limits) – Validated total PCB and TEQ prey (i.e., earthworm, insect/ invertebrate and plant) tissue data from site (adequately sensitive detection limits) or sufficient information to derive a site-specific bioaccumulation factor – Validated TEQ and total PCB egg tissue chemistry data (i.e., for the 11 co-planar congeners) from the site (adequately sensitive detection limits) or sufficient information to derive a site-specific BAF – Receptor-specific food web model input (exposure) parameters – Total PCB and TEQ avian dietary TRVs – TEQ and total PCB egg-based TRVs				
	RQ3: Do total PCB concentrations in floodplain soils and associated biota pose unacceptable ecological risk to **insectivorous birds** (e.g., house wren)? **ME1**- Compare modeled dietary total PCB and possibly TEQ[1] exposure to TRVs (calculate HQs). **ME2**- Compare modeled egg-based TEQ and possibly total PCB[1] exposure to TRVs (calculate HQs). **ME3** – Evaluate AOC-specific reproductive output for the house wren and other avian species.	– Validated soil chemistry (0-6 inches bgs, adequately sensitive detection limits) – Receptor-specific food web model input (exposure) parameters – Total PCB and TEQ-based avian TRVs for selected receptor (dietary) – TEQ and total PCB egg-based TRVs – Results of site-specific productivity studies		– If the NOAEL-based HQ <1 assuming a SUF of 1 for total PCBs, then risk to insectivorous birds is considered to be unlikely. – If the HQs>1, conduct a more refined spatial evaluation of receptor based on specific habitat requirements. – Use weight of evidence approach to evaluate all lines of evidence and additional supporting information.		No data collection recommended.

[1] The determination of whether these HQs will be calculated for each receptor and exposure scenario for total PCBs and/or TEQs will be made based on the outcome of the review of the available toxicity data during the TRV development process.

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Supplemental Remedial Investigations/Feasibility Studies
Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan

Table 6-1 - Exposed Sediment Data Quality Objectives

STEP 1 State the Problem	STEP 2 Identify the Decisions (Risk Questions and Associated Endpoints)	STEP 3 Identify the Inputs to the Decisions	STEP 4 Define Study Boundaries	STEP 5 Develop Decision Rules	STEP 6 Specify Tolerable Limits on Errors	STEP 7 Describe the Sampling Design
	RQ4: Do total PCB concentrations in floodplain soil and associated biota pose unacceptable ecological risk to local populations of **carnivorous mammals** (e.g., red fox)? **ME1**- Compare modeled dietary total PCB exposure to TRVs (calculate HQs).	– Validated soil chemistry (0-6 inches bgs, adequately sensitive detection limits) – Validated small mammal tissue chemistry data (adequately sensitive detection limits) or sufficient information to derive a site-specific BAF – Receptor-specific food web model input (exposure) parameters – Total PCB mammalian TRVs for selected receptor		– If the NOAEL-based HQ <1 assuming a SUF of 1 for total PCBs, then risk to carnivorous birds and mammals is considered to be unlikely. – If the HQs>1, conduct a more refined spatial evaluation of receptor based on specific habitat requirements. – Use weight of evidence approach to evaluate additional supporting information.	– Food web/dietary intake exposure models incorporate many uncertainties which are typically mitigated to a degree through the incorporation of conservatism. Similarly, TRVs are generic and incorporate a high degree of conservatism. Thus, the HQs calculated will result in an acceptable level of conservatism and will minimize the chance of false negative findings. – Small mammal and bird tissues are an important element in the food chain for carnivorous birds and mammals. Ten mouse samples and ten adult robin samples have been collected within the Plainwell Dam area. These data may not adequately represent the range of potential PCB exposure in Area 1. However, these data, combined with MSU data available from the former Trowbridge Impoundment, can be used to develop BAFs to model total PCB tissue concentrations for these tissue types.	No data collection recommended.
	RQ5: Do total PCB concentrations in floodplain soils and associated biota pose unacceptable incremental ecological risk to **carnivorous birds** (e.g., red-tailed hawk)? **ME1**- Compare modeled dietary total PCB exposure to TRVs (calculate HQs).	– Validated soil chemistry (0-6 inches bgs, adequately sensitive detection limits) – Validated prey tissue (i.e., small mammals, amphibians, and birds) chemistry data (adequately sensitive detection limits) or sufficient information to derive a site-specific BAF – Receptor-specific food web model input (exposure) parameters – Total PCB avian TRVs for selected receptor (dietary)				

Notes:

TRVs= toxicity reference values
RQ = risk question
TEQ = toxic equivalent
ME = measurement endpoint
total PCB = total polychlorinated biphenyl
HQ = hazard quotient
bgs = below ground surface
NOAEL = no observed adverse effects level
SUF = site use factor
MSU = Michigan State University
BAF = bioaccumulation factor
BERA = baseline ecological risk assessment

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Supplemental Remedial Investigations/Feasibility Studies
Area 1 Work Plan Supplement: Baseline Ecological Risk Assessment Work Plan

Table 6-2 -- Summary of Area 1 Floodplain Soil and Terrestrial Biota Data[1]

Investigation	Number of Locations	Number of Samples
Floodplain Soil/Exposed Sediment		
1993/1994 Former Impoundment Sampling	42	147
1993/94 RI Sampling	29	67
1993 TBSA Soil Sampling	8	8
2000 Focused Soil Sampling	30	92
2001 USEPA Sampling	132	757
2008 Plainwell No. 2 Dam Floodplain Sampling	95	302
2008 Plainwell No. 2 Dam Bank Sampling	78	265
2003 TCRA Design Bank Sampling	82	82
2007/08 SRI Bank Sampling	11	33
2008 Plainwell Dam TCRA Confirmation Sampling	95	302
Total	602	2055
Earthworms		
1993/1994 Biota Investigation	3	3
Small Mammals		
1993/1994 Biota Investigation	10	10
Adult Birds		
2003 MSU Data Collection	10	10

Notes:

[1] In addition to the data listed here, MDEQ collected soil data in the Plainwell Dam area and the Plainwell No. 2 Dam area in 2008. These data will be reviewed to assess consistency, representativeness and usability in the Area 1 BERA to determine the appropriate means by which that information will be

BERA = Baseline Ecological Risk Assessment
EPCs = exposure point concentrations
MDEQ = Michigan Department of Environmental Quality
MSU = Michigan State University
RI = remedial investigation
SRI = supplemental remedial investigation
TBSA = terrestrial biota sampling area
TCRA = time-critical removal action
USEPA = United States Environmental Protection Agency

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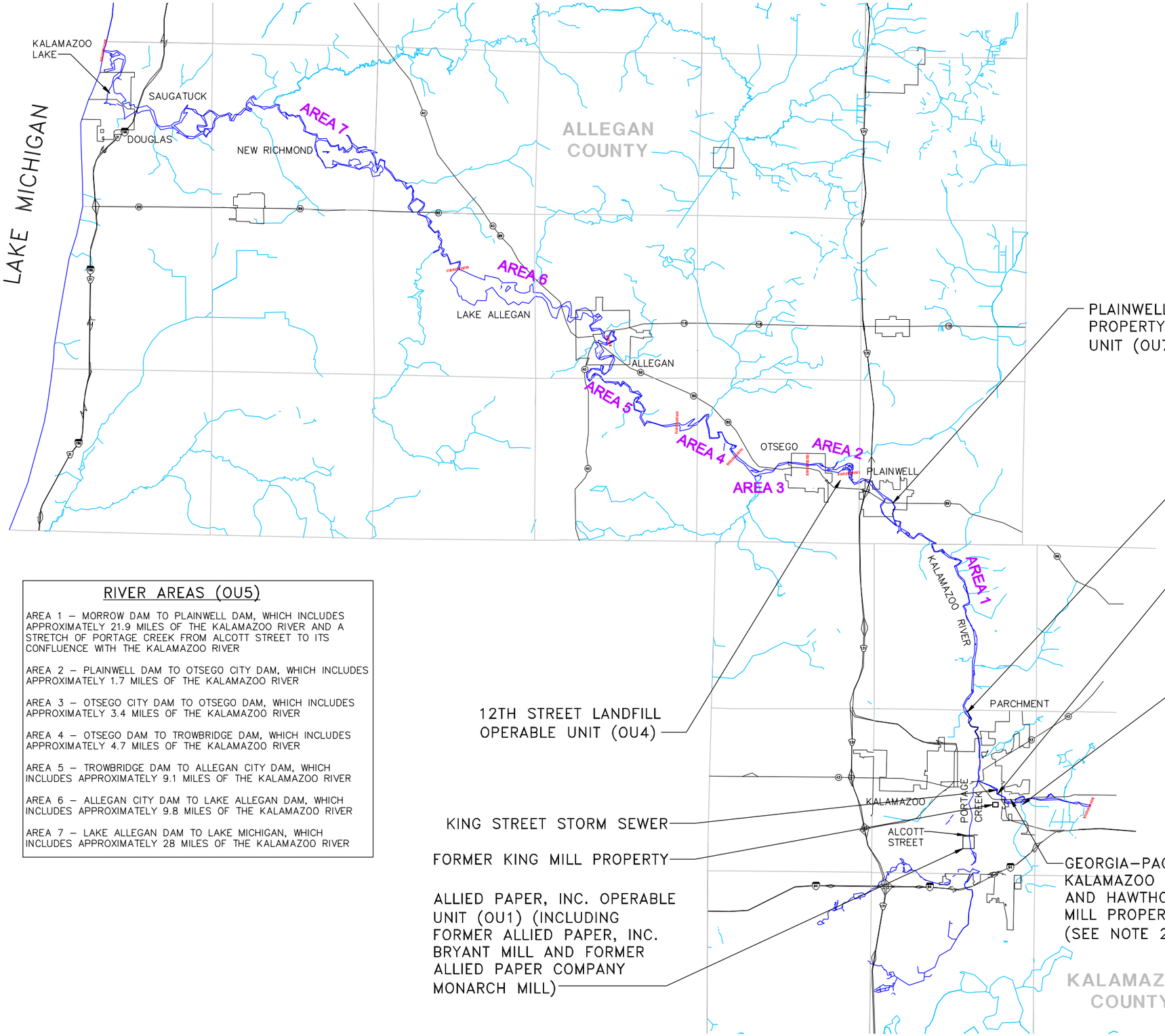
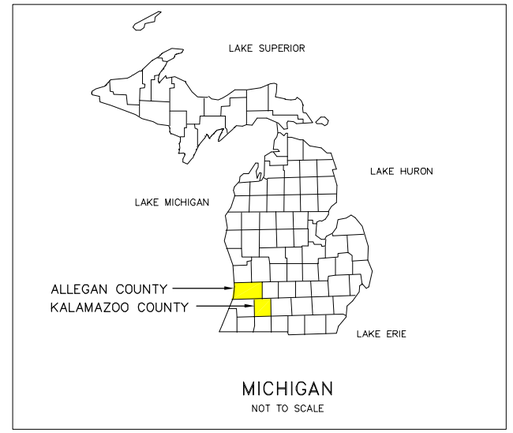
Figures





NOTES:

1. ALLEGAN AND KALAMAZOO COUNTY MAPPING OBTAINED FROM MICHIGAN RESOURCE INFORMATION SYSTEM.
2. OU6 IS CURRENTLY A RELATIVELY SMALL PART OF THE PARCEL COMPRISING BOTH MILLS.

LEGEND:

LIMITS OF RIVER AREAS WITHIN OU5

RIVER AREAS (OU5)

AREA 1 – MORROW DAM TO PLAINWELL DAM, WHICH INCLUDES APPROXIMATELY 21.9 MILES OF THE KALAMAZOO RIVER AND A STRETCH OF PORTAGE CREEK FROM ALCOTT STREET TO ITS CONFLUENCE WITH THE KALAMAZOO RIVER

AREA 2 – PLAINWELL DAM TO OTSEGO CITY DAM, WHICH INCLUDES APPROXIMATELY 1.7 MILES OF THE KALAMAZOO RIVER

AREA 3 – OTSEGO CITY DAM TO OTSEGO DAM, WHICH INCLUDES APPROXIMATELY 3.4 MILES OF THE KALAMAZOO RIVER

AREA 4 – OTSEGO DAM TO TROWBRIDGE DAM, WHICH INCLUDES APPROXIMATELY 4.7 MILES OF THE KALAMAZOO RIVER

AREA 5 – TROWBRIDGE DAM TO ALLEGAN CITY DAM, WHICH INCLUDES APPROXIMATELY 9.1 MILES OF THE KALAMAZOO RIVER

AREA 6 – ALLEGAN CITY DAM TO LAKE ALLEGAN DAM, WHICH INCLUDES APPROXIMATELY 9.8 MILES OF THE KALAMAZOO RIVER

AREA 7 – LAKE ALLEGAN DAM TO LAKE MICHIGAN, WHICH INCLUDES APPROXIMATELY 28 MILES OF THE KALAMAZOO RIVER

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AREA 1 WORK PLAN SUPPLEMENT: HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

KALAMAZOO RIVER SRI/FS AREAS 1 THROUGH 7

ARCADIS

FIGURE **1-1**

CITY: SYRACUSE, NY DIV/GROUP: 141/ENVCAD DB: LJP KES LD:(Opt) PIC:(Opt) PM:(Reqd) TM: D.PROFUSEK LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0064539\0001\00771\DWG\64539B01.DWG LAYOUT: 1-1SAVED: 6/22/2010 2:43 PM ACADVER: 17.0S (LMS TECH) PAGESETUP: ---PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 6/22/2010 2:43 PM BY: SINSABAUGH, KATE
XREFS: IMAGES: PROJECTNAME: ---

PLAINWELL

PLAINWELL DAM

MAIN ST

M-89

OTSEGO

PLAINWELL
No. 2 DAM

US-131

GULL RD

FLOW

GALESBURG

PARCHMENT

MORROW LAKE DAM

US-131

KALAMAZOO

E MICHIGAN AVE

KING HWY

I-94 BL

KALAMAZOO AVE

US-131

PORTAGE CREEK

ALCOTT ST

I-94

LEGEND:

- ROAD
- KALAMAZOO RIVER
- CREEKS/RIVERS/STREAMS/LAKES
- INCORPORATED AREA

0 1.3 2.6 Miles

GRAPHIC SCALE

NOTES:

1. AERIAL IMAGE DERIVED FROM ORTHOGRAPHIC DATA BY AIR LAND SURVEYS, INC., KALAMAZOO RIVER FLOWN 4/24/99, PORTAGE CREEK FLOWN 4/27/00.
2. BASEMAPPING PROVIDED BY THE MICHIGAN CENTER FOR GEOGRAPHIC INFORMATION.

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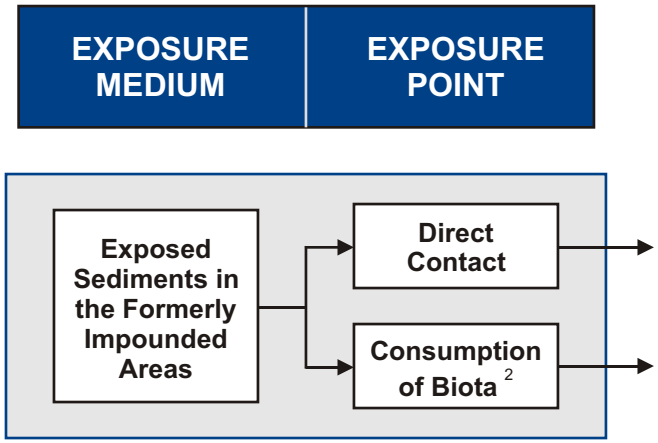
AREA 1 - MORROW LAKE DAM TO PLAINWELL DAM

ARCADIS

FIGURE
1-2

SYR-90 MTK KES
KRSG Risk Assessment (B0064539.0001.00771)
Q:\KRSG\MorrowDamToPlainwellDam\SRI_EcoRisk_HHrisk_WP\mxd\Area 1 General Figure.mxd - 6/30/2009 @ 9:32:01 AM



EXPOSURE ROUTE(S)	AREA 1 TERRESTRIAL EXPOSURE PATHWAYS									
	PLANTS	SOIL INVERTS	OMNIVOROUS BIRDS	OMNIVOROUS MAMMALS	INSECTIVOROUS BIRDS	INSECTIVOROUS MAMMALS	VERMIVOROUS BIRDS	VERMIVOROUS MAMMALS	CARNIVOROUS BIRDS	CARNIVOROUS MAMMALS
Uptake [1]	○	○								
Ingestion			○	○	●	○	●	●	●	●
Dermal Contact			◊	◊	◊	◊	◊	◊	◊	◊
Ingestion			○	○	●	○	●	●	●	●

LEGEND

- ● = Potentially complete exposure pathway
- ◊ = Potentially complete exposure pathway, expected to be minor - not quantitatively evaluated
- ○ = Potentially complete pathway but will not be quantitatively evaluated because exposure expected to be minimal compared to other pathways being evaluated or no toxicity expected based on Site-Wide BERA (CDM 2003a)

NOTE:

[1] Uptake is defined as all exposure routes (i.e., absorption, ingestion and inhalation)

[2] Contaminated biota may include plants, invertebrates, small mammals, reptiles, amphibians and birds.

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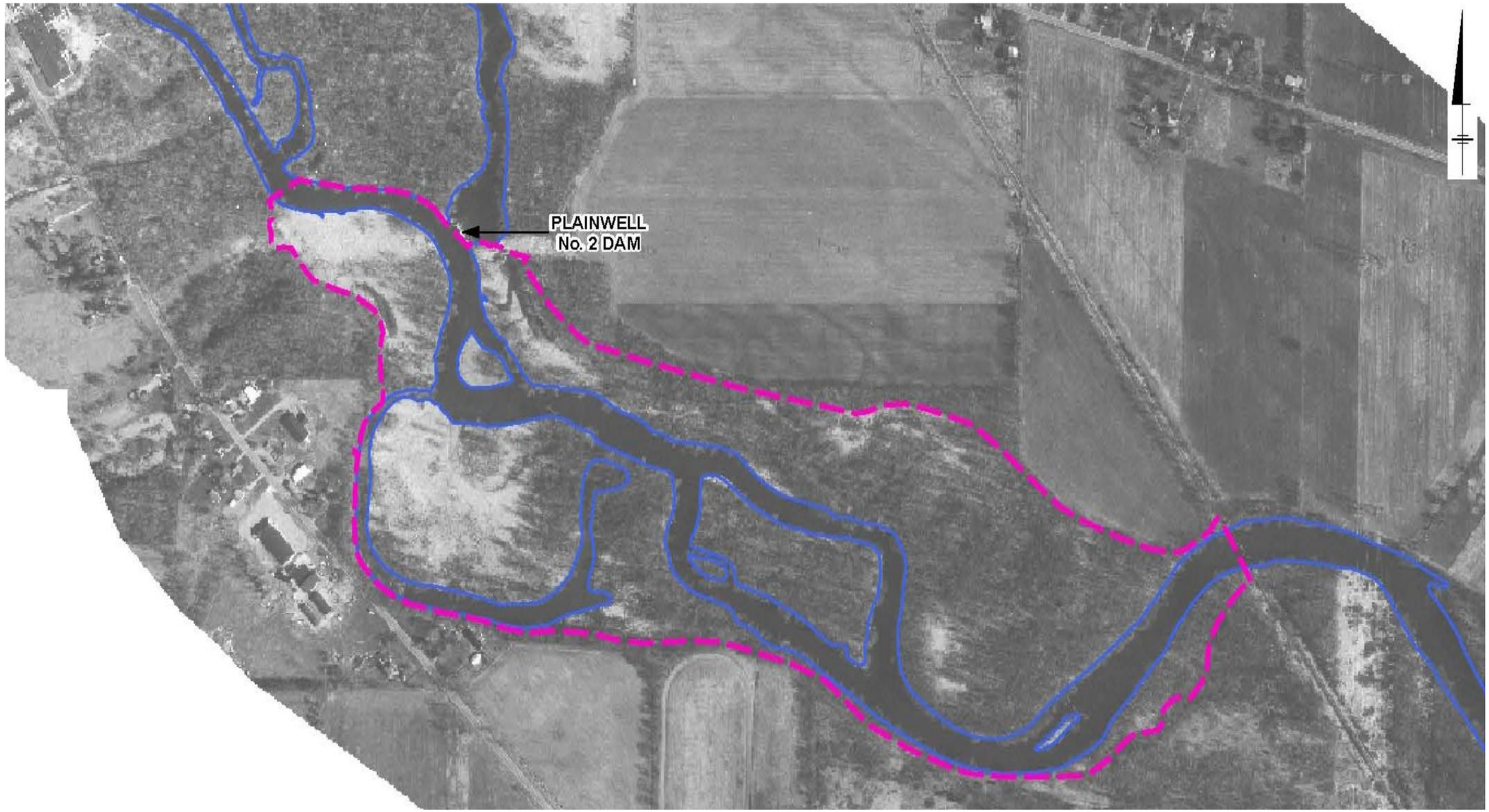
AREA 1 WORK PLAN SUPPLEMENT: HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

ECOLOGICAL CONCEPTUAL SITE MODEL FOR TERRESTRIAL HABITAT IN THE FORMERLY IMPOUNDED AREAS OF AREA 1

ARCADIS

FIGURE 2-1



LEGEND:

PLAINWELL NO. 2 DAM INVESTIGATION AREA ESTABLISHED TO INCLUDE THE HISTORIC INUNDATION AREA (APPROXIMATE)

EXISTING SHORELINE (APPROXIMATE)

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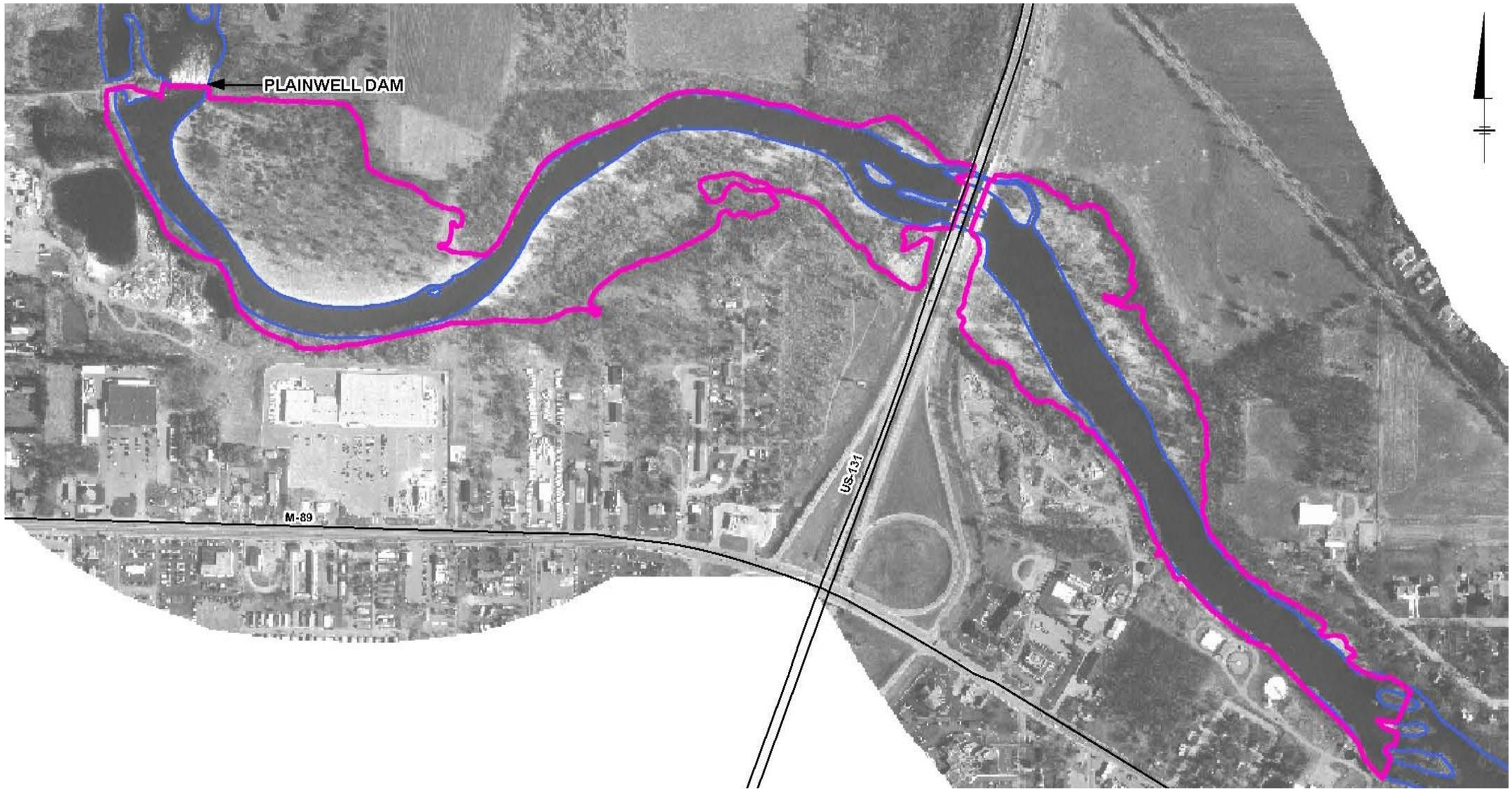
AREA 1 WORK PLAN SUPPLEMENT: HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

PLAINWELL NO. 2 DAM AREA EXPOSURE DOMAIN

ARCADIS

FIGURE
3-1

06/22/09 SYRACUSE-141ENV-DJHOWES
B0064539\0001\00771\CDR\64539g04.CDR



LEGEND:

LIMITS OF FORMER INUNDATION IN THE PLAINWELL DAM AREA (APPROXIMATE)

EXISTING SHORELINE (APPROXIMATE)

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AREA 1 WORK PLAN SUPPLEMENT: HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

PLAINWELL DAM AREA EXPOSURE DOMAIN

ARCADIS

FIGURE
3-2

06/22/2010 SYRACUSE-141ENV-DJHOWES
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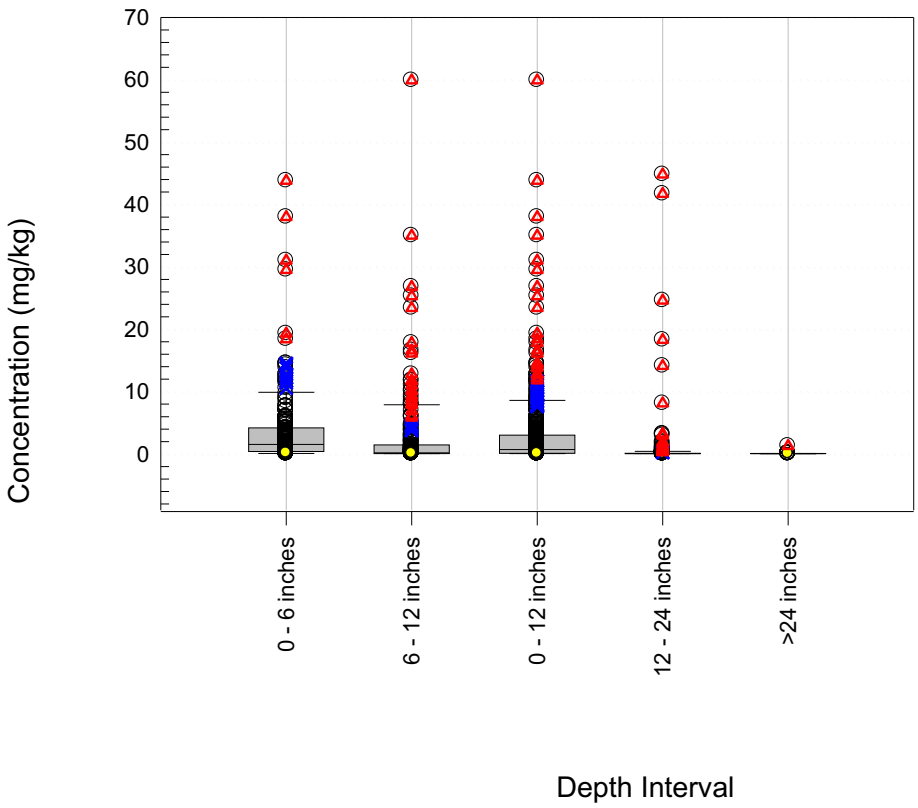

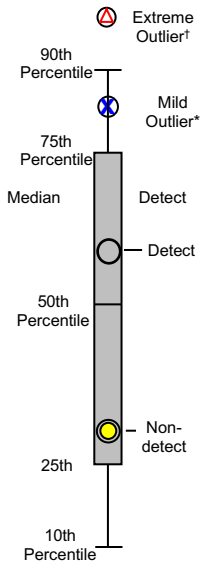

Depth Interval	Units	Sample Size			ND Range		Detects					Percentiles (All Data)		
		NDs	Detects	Total	Min	Max	Min	Max	Mean	Median	SD	25th	50th	75th
0 - 6 inches	mg/kg	17	169	186	0.05	0.17	0.03	43.8	4.1	1.8	6.3	0.42	1.5	4.2
6 - 12 inches	mg/kg	65	124	189	0.05	0.23	0.04	59.9	3.7	0.68	7.8	0.08	0.20	1.5
0 - 12 inches	mg/kg	82	293	375	0.05	0.23	0.03	59.9	3.9	1.5	6.9	0.11	0.71	3.0
12 - 24 inches	mg/kg	151	55	206	0.05	0.17	0.04	44.8	3.2	0.23	9.0	0.07	0.08	0.12
>24 inches	mg/kg	21	2	23	0.05	0.09	0.11	1.3	0.70	0.70	0.83	0.06	0.07	0.09

Notes:

† Result value is < 25th percentile - 3*IQR or > 75th percentile + 3*IQR

* Result value is < 25th percentile - 1.5*IQR or > 75th percentile + 1.5*IQR

NA = value not applicable due to frequency of detection

ND = non-detect

IQR = interquartile range equals the 3rd quartile (75th percentile) - 1st quartile (25th percentile)

Reporting limit is used for non-detects unless otherwise noted.

Values less than 10 are reported to 2 significant figures. Values greater than 10 are reported to 3 significant figures.

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AREA 1 WORK PLAN SUPPLEMENT: HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SOIL BOX AND WHISKER PLOT -TOTAL PCBS IN PLAINWELL NO. 2 DAM AREA

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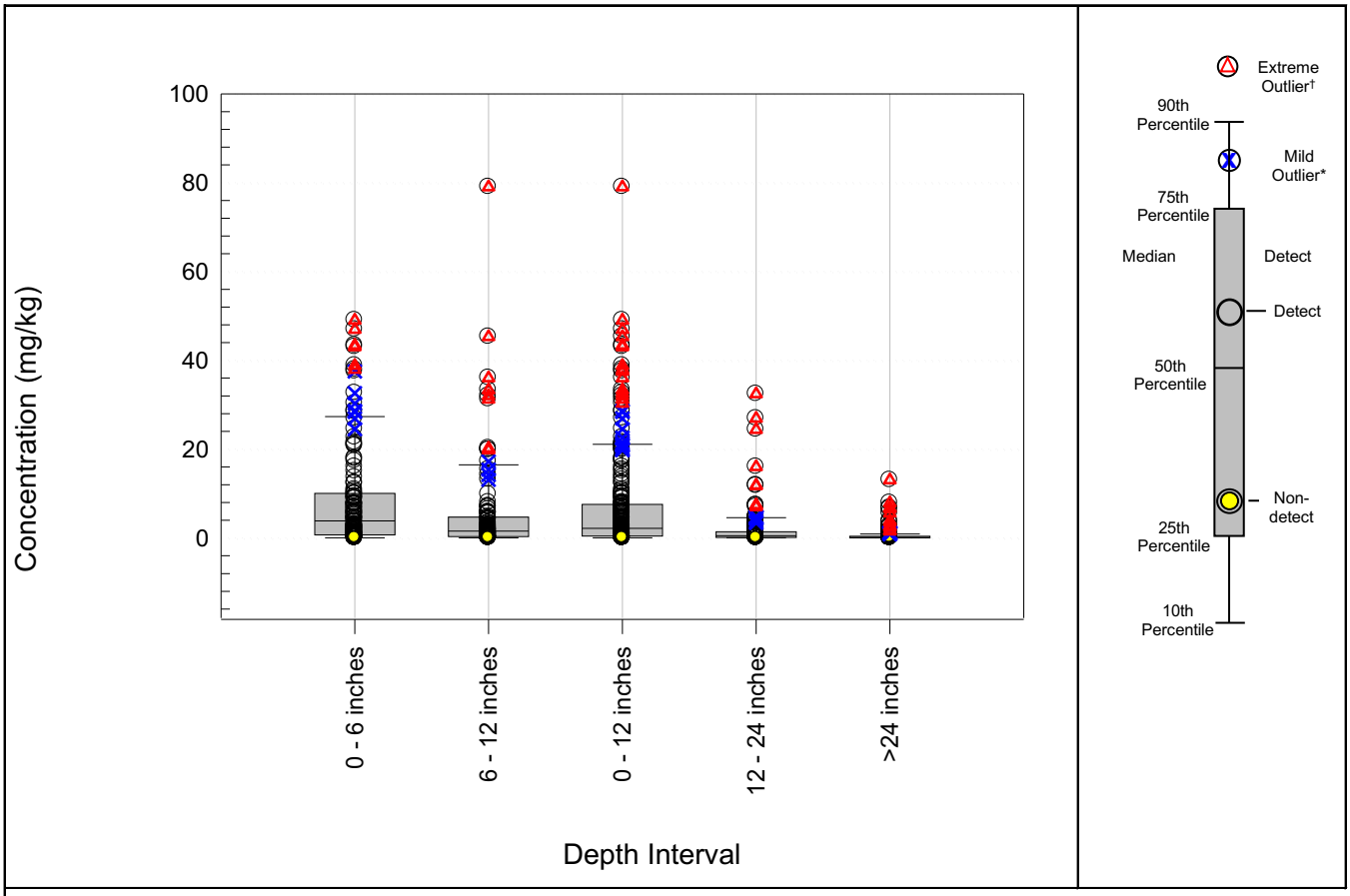
FIGURE
3-3



Depth Interval	Units	Sample Size			ND Range		Detects					Percentiles (All Data)		
		NDs	Detects	Total	Min	Max	Min	Max	Mean	Median	SD	25th	50th	75th
0 - 6 inches	mg/kg	14	102	116	0.04	0.07	0.0034	49.0	9.6	5.2	11.9	0.72	3.8	10.0
6 - 12 inches	mg/kg	7	96	103	0.03	0.06	0.008	79.0	5.7	1.7	11.4	0.31	1.6	4.6
0 - 12 inches	mg/kg	21	198	219	0.03	0.07	0.0034	79.0	7.7	2.6	11.8	0.43	2.2	7.5
12 - 24 inches	mg/kg	7	110	117	0.04	0.07	0.00257	32.4	2.2	0.55	5.0	0.11	0.51	1.4
>24 inches	mg/kg	31	217	248	0.04	0.13	0.0063	13.1	0.52	0.16	1.3	0.06	0.14	0.38

Notes:

† Result value is < 25th percentile - 3*IQR or > 75th percentile + 3*IQR

* Result value is < 25th percentile - 1.5*IQR or > 75th percentile + 1.5*IQR

NA = value not applicable due to frequency of detection

ND = non-detect

IQR = interquartile range equals the 3rd quartile (75th percentile) - 1st quartile (25th percentile)

Reporting limit is used for non-detects unless otherwise noted.

Values less than 10 are reported to 2 significant figures. Values greater than 10 are reported to 3 significant figures.

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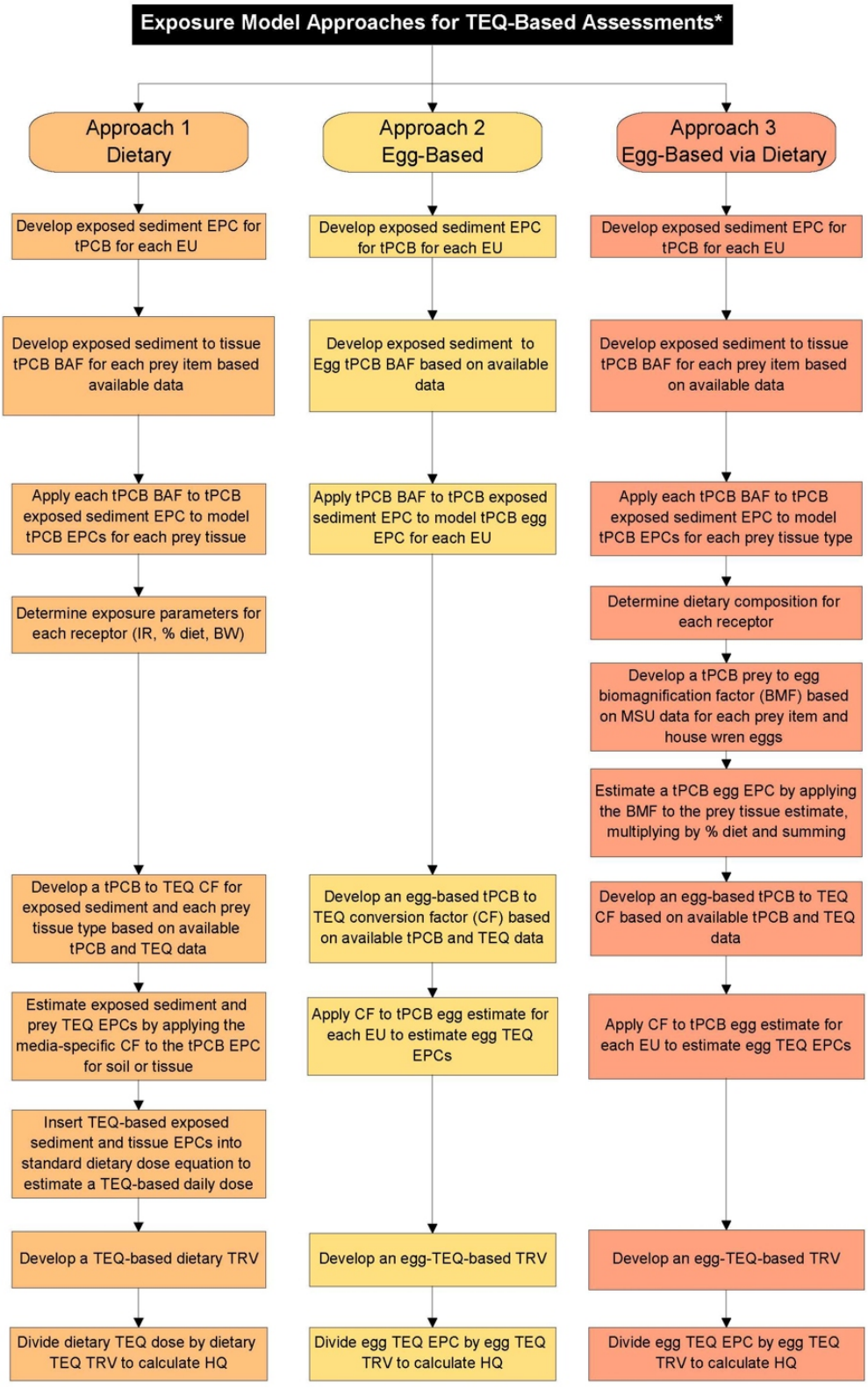
AREA 1 WORK PLAN SUPPLEMENT: HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT WORK PLAN

SOIL BOX AND WHISKER PLOT - TOTAL PCBS IN FORMER PLAINWELL IMPOUNDMENT

ARCADIS

FIGURE
3-4



NOTE:
* For total PCB-based assessments, use same approaches but do not apply CFs to exposure estimates. Compare daily dose or egg EPC to total PCB-based TRVs.

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AREA 1 WORK PLAN SUPPLEMENT: BASELINE ECOLOGICAL RISK ASSESSMENT WORK PLAN

EXPOSURE MODEL APPROACHES

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FIGURE
3-5

06/22/2010 SYRACUSE-141ENV-DJHOWES
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